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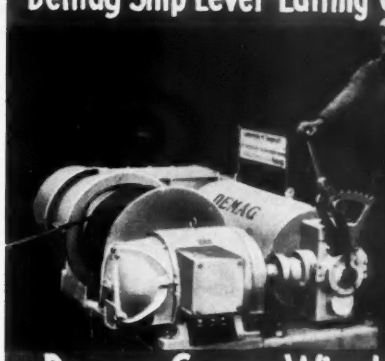
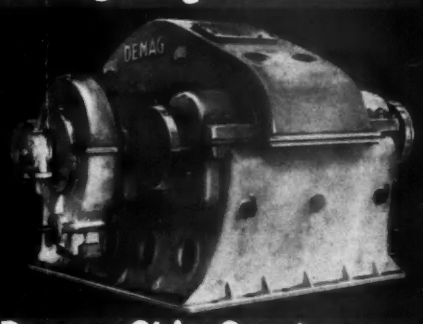


Demag Cargo Winches



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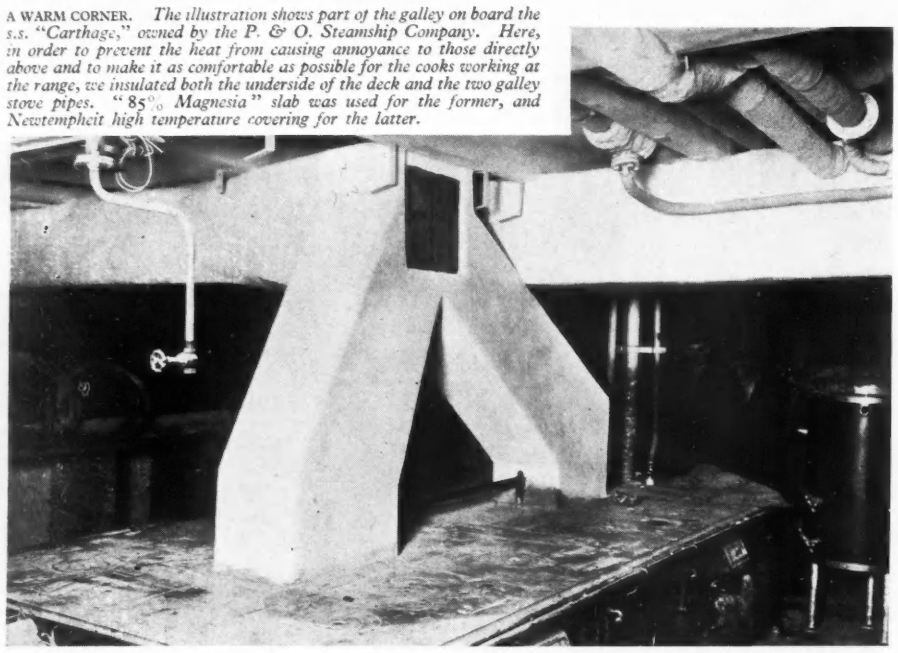

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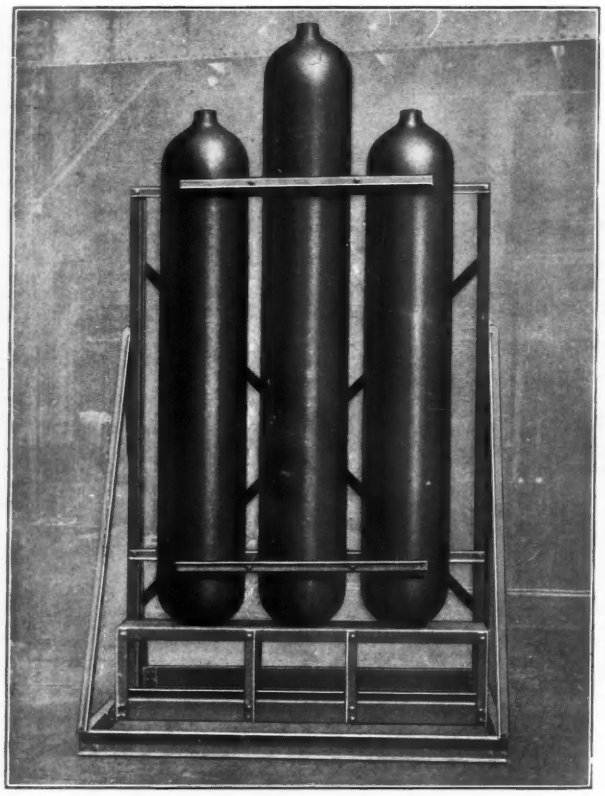

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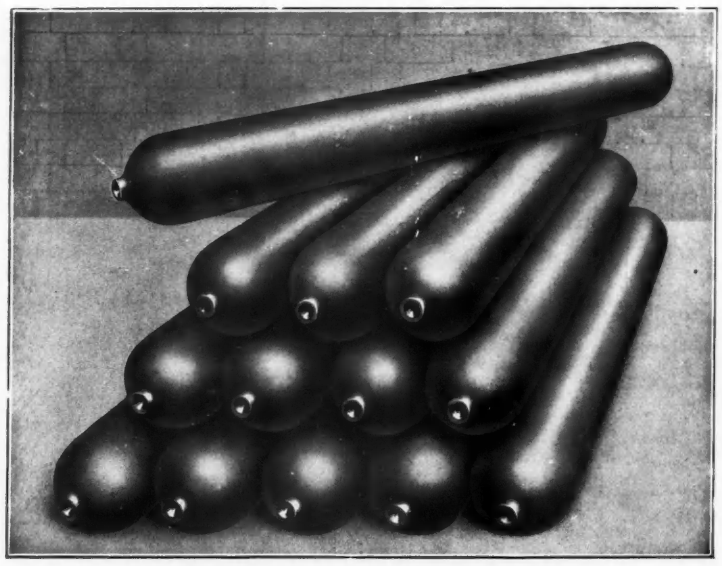

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A Seven-Day Journal

The Shipbuilding Outlook.

IN the course of a speech made at the luncheon which followed the successful launch of the new L.M.S. Railway paddle steamer, the "Marchioness of Lorne," at Govan, last week, Sir Alexander Kennedy expressed the opinion that the British Shipping (Assistance) Bill would lead to orders for new cargo tonnage and a reduction of unemployment in the shipbuilding industry. At the present time, Sir Alexander pointed out, unemployment in the shipbuilding trades was very nearly 46 per cent. Although a very welcome and growing improvement had taken place in the industry since the beginning of 1934, the greatest optimist would hardly claim that the industrial outlook was all that could be desired. When compared with the immediately preceding years of acute depression, there was certainly cause for gratification, but if comparison could be made with the year 1929, which to-day was reckoned to be a normal year, then the industry had still a long way to go before prosperity was reached. The tonnage under construction in 1934 was approximately 597,000, as against 1,560,000 in 1929. These figures referred only to merchant tonnage and did not take into account the effect of the larger amount of Admiralty work which had greatly benefited the industry. Speaking further on the British Shipping (Assistance) Bill, Sir Alexander said that already in several districts inquiries were being made for new cargo tonnage in anticipation of the scheme coming into operation, and he was of the opinion that quite a number of ships would be ordered as soon as the Committee which was to be set up to deal with that section of the Bill got to work. Industry would be greatly benefited and unemployment reduced by the passing of the measure. The task before British industry was still a formidable one; but, given the right atmosphere, it could be accomplished.

The Late Sir Harold Lincoln Tangye.

IT is with deep regret we have to record the death of Sir Lincoln Tangye, which took place in London on Sunday, February 24th. He was the eldest son of the late Sir Richard Tangye, who, with his brother George, was the founder of the well-known engineering firm of Tangyes, Ltd., Birmingham. Sir Lincoln was born on January 16th, 1866, and was educated at Queenswood College, Hampshire, and Owens College, Victoria University, Manchester. He then served a full apprenticeship in the shops and drawing-office in his father's works. Subsequently he visited Australia, New Zealand, and South Africa in connection with the firm's agencies and branch houses in those countries. On his return to Birmingham he took an active part in the commercial side of the business, maintaining the close touch he had already established with the Australian and South African markets. Later he became deputy chairman of Tangyes, Ltd., and remained on the board until July, 1934, when he resigned owing to ill-health. One of his chief interests was the development of gas and oil engines, and in 1931 he read a paper on the subject before the Royal Society of Arts, of which he was a Fellow. He was also a member of the Institution of Mechanical Engineers and of the Birmingham Association of Mechanical Engineers, and an F.R.G.S. Apart from his business tours, he travelled widely in many parts of the world, and recorded some of his impressions in two books:—"In New South Africa: Travels in the Transvaal and Rhodesia" (1896), and "In the Torrid Sudan" (1910).

Road Bridge Design.

IN a letter recently sent to highway authorities, the Minister of Transport, Mr. Hore-Belisha, draws attention to the fact that the Royal Fine Art Commissions of England and Scotland are ready to advise without charge on the suitability of bridge designs. He expresses the hope that authorities contemplating new projects of importance, or the construction or alteration of bridges at sites of historical interest or natural beauty, will make a practice of consulting the appropriate Commission before they commit themselves to a particular design. Even before questions of design are reached, the Ministry's divisional road engineer should, he points out, be informed of the proposals, so that complete co-operation can be secured at all stages. The Minister further urges upon all local authorities contemplating the alteration of ancient bridges or the erection of new ones, the great importance of securing at the outset reliable expert advice upon the design, not merely from the standpoint of the stability of the structure, but also of its proportions and artistic character. Many bridges, pleasing in themselves and harmonious with their surroundings, he states, have been constructed by highway authorities, but he is conscious that, during the next few years, many other bridges will have to be built or reconstructed, and he feels that it would not be inappropriate if he were again to request the attention of highway authorities to the matter. When receiving applications for assistance from the Road Fund, he will require to be satisfied that these considerations are taken into account. There is, he states, no reason to assume that their observance will add to the cost of construction, and experience shows that bridges are more frequently criticised for undue elaboration than for well-proportioned simplicity.

The Late Mr. William Sisson.

ON Friday, February 22nd, the death took place at Gloucester of Mr. William Sisson, the founder and chairman of W. Sisson and Co., Ltd., of Gloucester. Mr. Sisson, who died in his eighty-first year, was born in 1853 at Gateshead-on-Tyne, and after completing his schooling was in 1869 apprenticed to R. and W. Hawthorn, of Newcastle-upon-Tyne. In 1874 he was awarded a Whitworth Scholarship, and after completing his scientific training at the College of Physical Science at Newcastle and the Royal College of Science, Dublin, he returned to Messrs. Hawthorn's works as a draughtsman. In 1878 he was appointed manager of the engine works and shipyard of Cox and Co., of Falmouth, where he remained for close upon eleven years. During that time he obtained a wide first-hand knowledge of ship construction and marine engineering construction and repair work, which laid the foundations of his own life's work. In 1889 he left Falmouth and took over the marine engine business of J. J. Seekings and Co., and was joined by his brother Mr. Arthur W. Sisson, W.Sc. Mr. Sisson took out many patents covering the design and development of the "Sisson" high-speed steam engine, and for some time he practised as a consulting engineer and naval architect. He was an old and valued member of the Institution of Mechanical Engineers, which he joined in 1881, and was also a member of the Institution of Naval Architects and the North-East Coast Institute of Engineers and Shipbuilders and the Gloucester Engineering Society.

Colonel R. E. B. Crompton's 90th Birthday.

WE are happy to record that the undermentioned "Cromptonians" are organising a function to celebrate the ninetieth birthday of Colonel R. E. B. Crompton, which falls on Friday, May 31st next. Sir Arthur Stanley has consented to preside at the banquet at which it has been decided to present him with a portrait of himself. Invitations will be issued in the names of men prominent in the electrical industry. Colonel Crompton has expressed the desire to hand the portrait in question to the Institution of Electrical Engineers, and the Council of that Institution has signified its pleasure at the suggestion. Subscriptions towards the cost of the portrait are invited and are limited to one guinea. Those desiring to subscribe are asked to forward their subscription to the hon. secretary and treasurer as early as possible and in any case not later than March 31st next. Subscribers will be asked later on to send in their signature for inclusion in an album to be retained by Colonel Crompton as a memento of the occasion. The provisional committee of "Cromptonians" consists of Mr. S. L. Brunton, Lieut.-Colonel K. Edgcumbe, Mr. E. J. Fox (hon. secretary and treasurer), Mr. J. W. Meares, Mr. A. H. Pott, Sir John Snell, and Sir James Swinburne. All communications should be addressed to the hon. secretary at the Manor House, Stanton-by-Dale, near Nottingham.

Machinery Orders for China.

FOLLOWING the annual meeting of the Chinese Government Purchasing Commission, which was held at the Chinese Legation at 49, Portland-place, London, W.1, on Monday, February 25th, the announcement was made that the sum of £200,000 is to be spent on machine tools and workshop equipment for China, which will be ordered from British firms. The equipment is, we are informed, for the Ministry of Industry's National Shops at Shanghai, and for the railway shops of the Canton–Hankow Railway. As the actual orders have, however, still to be placed, no further information is yet available. The meeting was presided over by His Excellency the Chinese Minister, and among those who attended were Sir Arthur Balfour, Sir Basil Blackett, Sir Ralph Wedgwood, and Dr. C. C. Wang. The report for 1934 showed a large increase of orders placed in Great Britain compared with 1933; and the total value of the 1934 contracts was given as £1,849,979, which brought the total orders placed by the Commission since it began its work to £2,915,025. The weight of materials shipped to China last year exceeded 89,430 tons.

New Telephone Developments.

ON Tuesday morning, February 26th, Sir Kingsley Wood, the Postmaster-General, formally opened the new City Telephone Sales Office in St. Martin's-le-Grand. The office is equipped with demonstration models, and is intended to give full information with regard to telephone services. In the course of his speech, the Postmaster-General referred to four new developments which would shortly, he said, be brought into operation. These included, first, the auto-dial, which permitted a telephone subscriber to choose a number of other subscribers with whom it was desired to communicate frequently, to have them recorded on the machine, and to communicate with them by pressing a lever. The second development was a new type of house-telephone system, which would enable callers to be put through from one extension to another, or from any extension to the public exchange system, without the intervention of a private branch operator. The third item was a new method of indicating the lapse of time on trunk calls. Many persons found the present verbal announcement of three minutes or six minutes somewhat disturbing, and at the large trunk centres there would be substituted a time signal, rather similar to the B.B.C. time signals. The fourth new development was a talking clock. Any London subscriber who wished to get the right time would be able to ring up the talking clock and would then hear the time announced in hours, minutes, and seconds. The only cost to subscribers would be the ordinary charge for a call to Central London.

Imperial Air Mails.

IN welcoming the delegates to the Empire Air Mail Conference at Sydney, Australia, Mr. Parkhill, the Minister of Defence, criticised the British proposal to use flying boats on the England–Australia service. The flying-boat scheme would necessitate, he said, a new coastwise route between Darwin and Sydney, and the Commonwealth had already developed an overland service which they had no intention of abandoning. The cruising speed of flying-boats was 130 m.p.h., and that of the aircraft now being used 140 m.p.h., so that night flying seemed to be the only means of accelerating the service under the British plans. Grave difficulty would be caused if the principle were adopted that all first-class mail should be carried by air without surcharge. The largest type of aircraft would be required. The added cost to the Commonwealth of the British delegates' proposal would be £200,000 sterling annually, which, he said, required the most careful consideration. The British estimate was, admittedly, lower, but it involved petrol concessions which would cause heavy indirect loss to the Commonwealth revenue. It now seems that a coastwise route from Darwin to Brisbane will not be included in the agreement, the Australian authorities remaining adamant in their desire to preserve the existing inland routes, which serve outback areas. Flying-boats will probably carry the mails between Singapore and Darwin, and provision at Darwin for a flying-boat terminus has already been approved. The question of expediting the journey to Sydney without detriment to outlying points is to be explored.

The Chamber of Shipping Report.

THE annual report of the Chamber of Shipping of the United Kingdom which was presented at the fifty-eighth annual meeting of the Chamber, held in London on Thursday, February 28th, states that in spite of the improvement in British trade and the slight recovery in international trade, shipping remains one of the depressed industries of the world. The growth of trade barriers, including subsidies for building and running ships, has at last forced Great Britain to act in self-defence. Outstanding events of the year were, it recalls, the introduction by the Government of the British Shipping (Assistance) Bill and the preparations made for an International Conference for the Rationalisation of Shipping. Freights were slightly better in 1934 than in 1933, but were not enough to pay expenses including depreciation, still less to provide a reasonable return on capital. On the subject of shipbuilding the question of excess tonnage is discussed and analysed, and the opinion is given that it is impossible for shipbuilding to prosper so long as the surplus of tonnage remains. It is only when it has been eliminated as a result, at the earliest, of rationalisation, and, at the latest, of natural causes that the normal flow of shipbuilding orders can be resumed and shipbuilding restored to an economic basis. The effective rationalisation undertaken by British shipbuilders has assisted the industry in weathering the storm, but prosperity must, the report suggests, ultimately depend upon the revival of an economic demand for new tonnage. If this can be brought about by rationalisation in shipping, it will react favourably upon ancillary industries such as iron and steel, coal and engineering. With the scrapping that is now going on and that which may result from international action, the time will be brought nearer when shipbuilding will again be restored to the healthy state in which it can rely on the new construction needed to replace marine losses, wear and tear and the steady and moderate progress required for the expansion of trade upon which the revival of shipping ultimately depends.

Pedestrian Traffic Signals.

ON Tuesday, February 26th, at 11.45 a.m., the Mayor of the City of Westminster, Mr. F. G. Rudler, in the presence of the Minister of Transport, Mr. Hore-Belisha, put into operation the new automatic signals for pedestrians which have been fixed to existing traffic light standards at the north-east corner of Trafalgar Square, by St. Martin's-place and Duncannon-street. They are the first of their kind in London and differ from other traffic signals in that there is no amber light. There are two signals, one displaying the warning "Don't Cross" in red on a black background, and the other the injunction "Cross Now" in white on a black background. While pedestrians are crossing, during a period of about fifteen seconds, the traffic signals will stop the traffic.

The Development of Parsons Industrial Turbo Machinery.

No. VIII.

(*Continued from page 193, February 22nd.*)

MIXED-PRESSURE TANDEM TURBO-ALTERNATORS FOR THORNE COLLIERY.

ALL the mixed-pressure turbines constructed prior to 1909 had been single-cylinder machines. In that year a new design was developed by Messrs. Parsons in which the turbine consisted of two cylinders in tandem, each with its own steam chest, an obvious advantage for large machines using steam at two different pressures. The first mixed-pressure turbine of this type was built to the order of Pease and Partners, Ltd., and formed part of an order for three identical turbo-generating sets, each having a maximum output of 1500 kW at 3000 r.p.m. They were installed at the Thorne Colliery, near Doncaster, to generate power from the exhaust steam from the winding engines. The turbines were also noteworthy for another feature, namely, that their low-pressure cylinders were of the double-flow type. These turbines had, therefore, the distinction of being the first examples of the modern tandem arrangement of high-speed machines with double-ended low-pressure cylinders. They ante-dated, it will be observed, the famous 25,000-kW tandem machine built for Chicago in 1912, which was designed along the same lines, and was the first straightforward high-pressure turbine to have a high-pressure cylinder and a double-flow low-pressure cylinder on the same shaft. A two-cylinder turbine with the low-pressure cylinder constructed on the double-flow principle, was also built for Bankfoot power station in 1910, but in that machine the two cylinders were mechanically independent of each other, each driving its own alternator.

The mixed-pressure units for the Thorne Colliery were designed each to give an output of 750 kW when working with exhaust steam at an absolute pressure of 15 lb. per square inch, or an output of 1250 kW, with live steam at a gauge pressure of 150 lb., superheated to 516 deg. Fah. A maximum output of 1500 kW could be obtained from each machine by the use of a hand-operated by-pass valve admitting live steam to a lower stage of the high-pressure cylinder. The valve gear was similar to that with which the 750-kW mixed-pressure turbo-alternator for Burnyeat Brown and Co., Ltd., had been equipped, and which was illustrated in connection with the description of that machine.

FIG. 76—THREE 1500-KW MIXED PRESSURE TURBO-ALTERNATORS AT THORNE COLLIERY—1909

The appearance of the three 1500-kW mixed-pressure turbo-alternators at the Thorne Colliery is shown in the photograph reproduced in Fig. 76. The size of the low-pressure steam chest and piping of the machine in the foreground is very noticeable, while the two-pole exciters with their field magnets of the horse-shoe type will also be remarked.

THE DEVELOPMENT OF THE "DISC AND DRUM" TURBINE.

For the first twenty years of its existence the Parsons turbine was always constructed on the pure reaction principle, as exemplified in the pioneer machine of 1884. Underlying the design was the conviction of Sir Charles Parsons, which has now become a commonplace of turbine engineering, that moderate steam speeds, and consequently the expansion of the steam by a large number of small pressure drops, are necessary to the attainment of the highest efficiency. To provide for numerous small pressure drops at the high-pressure end of a turbine involved, however, not only a considerable length of rotor with many blade rows, but also the subjection of the interior of the machine for some distance to steam at high temperature and pressure. The high-pressure blading, moreover, had to be relatively short on account of the density of the steam, so that leakage over the blade tips became rather an important consideration, the system of preventing it by means of "end tightening" not having then been invented.

At the commencement of the present century a type of turbine in which the whole of the pressure drop of the steam took place in two to four stages only was developed in the United States by Dr. Curtis. The live steam passed from the steam chest through one or more expanding nozzles, entering the turbine at a very much reduced pressure and temperature, but at a very high velocity. It then acted by impulse on two or more blade rows on one of the turbine wheels, the moving blades having rows of fixed guide blades between them to reverse the direction of the flow. The steam then passed through more nozzles into the next compartment, acquiring fresh velocity in the process, this velocity being absorbed in driving another wheel. Turbines of this type were constructed in quite large sizes, being built in capacities of 9000 kW or more, but the principle of "velocity compounding" being inherently inefficient, the system fell into disuse. The expansion of high-pressure steam in nozzles, and the absorption of the high velocity acquired by a Curtis wheel was, nevertheless, so convenient a way of abstracting a large amount of energy from the steam, and thereby of reducing it to a more manageable condition that the combination of a Curtis wheel with a subsequent number of reaction stages appealed to many engineers as a good method of turbine design. Besides minimising the temperature and leakage difficulties, it permitted the use of a considerably shorter and stiffer rotor, and held out hopes of a somewhat cheaper construction with no great loss of efficiency.

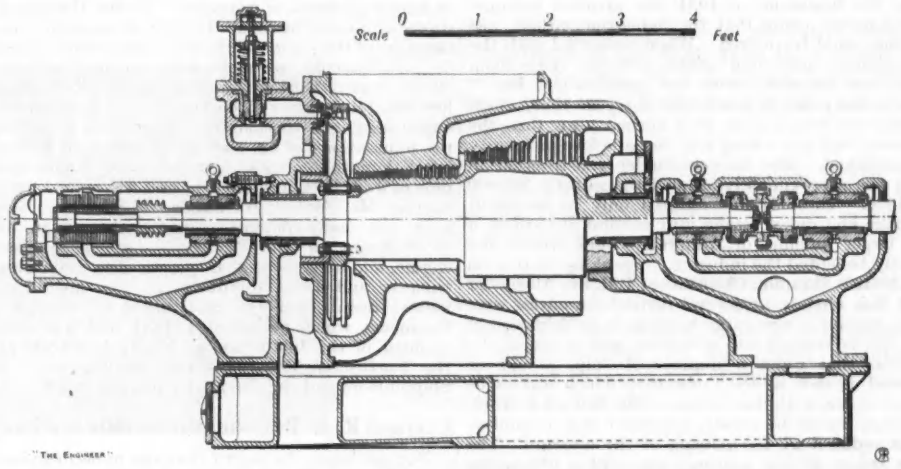


FIG. 77—SECTIONAL ARRANGEMENT OF 500-KW "DISC AND DRUM" TYPE TURBINE—1909

To examine the possibilities of this kind of machine in a practical manner, a turbine of the impulse reaction or "disc and drum" type was built by Messrs. Parsons in 1909. It was constructed primarily for the purpose of securing reliable data by experiments on a commercial scale. The machine was designed for an output of 500 kW at a speed of 3000 r.p.m., steam being supplied at a gauge pressure of 180 lb. per square inch superheated to 580 deg. Fah. and exhausting into a vacuum of 28in. The rotor carried a two-row Curtis wheel with a mean diameter of 34in., followed by thirty rows of reaction blading. These rows were arranged in seven groups of increasing height on two drum diameters. The first rows had a mean diameter of 14·5in. and the last a mean diameter of 23·25in., the blade heights increasing from 0·75in. initially to 4·25in. in the final rows.

A sectional drawing of the machine is given in Fig. 77 and a photograph of it on the test beds at the Heaton Works in Fig. 78. An inspection of the illustrations will show that the method adopted for securing steam balance of the rotor differed from that usually employed. The principle of the new arrange-

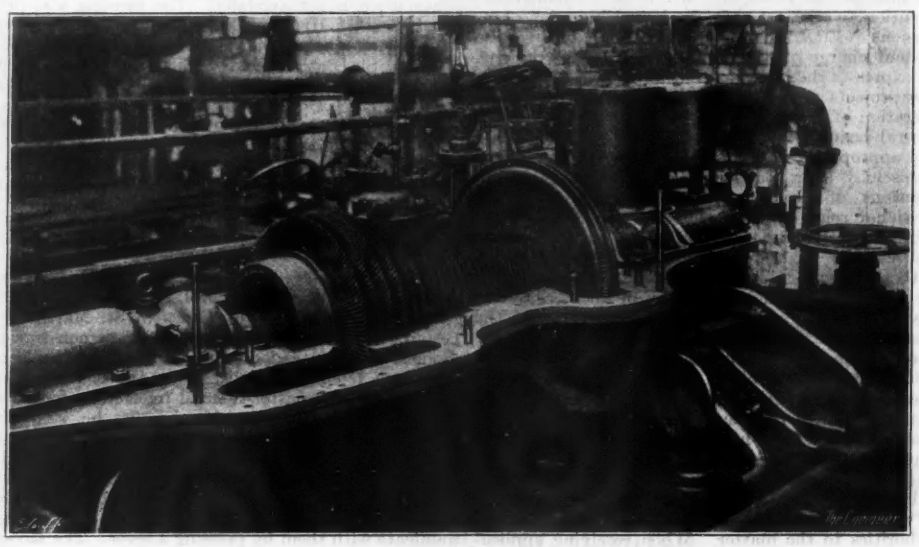


FIG. 78—"DISC AND DRUM" TYPE TURBINE ON TEST BED—1909

ment was the subject of a patent taken out in 1907. Owing to the introduction of the impulse wheel, difficulty was experienced in providing for a sufficiently large dummy piston to counterbalance the end pressure of the steam tending to move the rotor in the direction of the exhaust. To overcome this difficulty two separate dummy pistons were employed. One of these was fitted at the exhaust end of the rotor, and steam from an intermediate point of the turbine was led to the back of it by means of a passage cast in the cylinder cover. The pressure of the steam tended to push the rotor in the direction of the high-pressure end of the turbine, and thus to neutralise the thrust of the working steam on the blading and rotor. This effect was assisted by the other dummy piston, bolted to the upstream side of the Curtis wheel. The back of this dummy piston was connected to the condenser and thus subjected to a vacuum, thereby increasing the force tending to move the rotor against the pressure of the working steam. The device answered perfectly, so far as the balance of the rotor was concerned, but it had the defect that, owing to the dummies being so far apart, they were difficult to adjust equally on account of the expansion of the rotor when hot. It was consequently almost impossible to prevent a considerable leakage of steam at a useful pressure directly into the exhaust of the turbine.

Valuable experimental data were obtained from the machine and impulse reaction turbines for outputs of 2400 kW to 5000 kW were constructed the following year in the light of the information secured. The experimental machine was eventually sold for commercial work in 1912, its destination being the Wellington Jute Mills in India, where it was used for driving an existing alternator at 500 r.p.m. by means of speed reduction gearing.

THE APPLICATION OF THE TURBINE TO ROLLING MILL DRIVING.

Although the steam turbine is essentially a high-speed machine, the introduction of gearing has removed every limitation to its use that this characteristic might seem to impose. No better proof can be given of this fact than the successful application of the turbine to the driving of a steel works rolling mill, a kind of machinery which not only runs at a particularly low speed, but calls for frequent and violent fluctuations in the driving power required. A mixed-pressure turbine was supplied by Messrs. Parsons in 1910 for driving a three-high rolling mill at the Calderbank Iron and Steel Works of J. Dunlop and Co., Ltd., the turbine being connected to the rolls through double reduction gearing. Before proceeding with the description of this plant a few words may be said about previous developments in high-speed gearing.

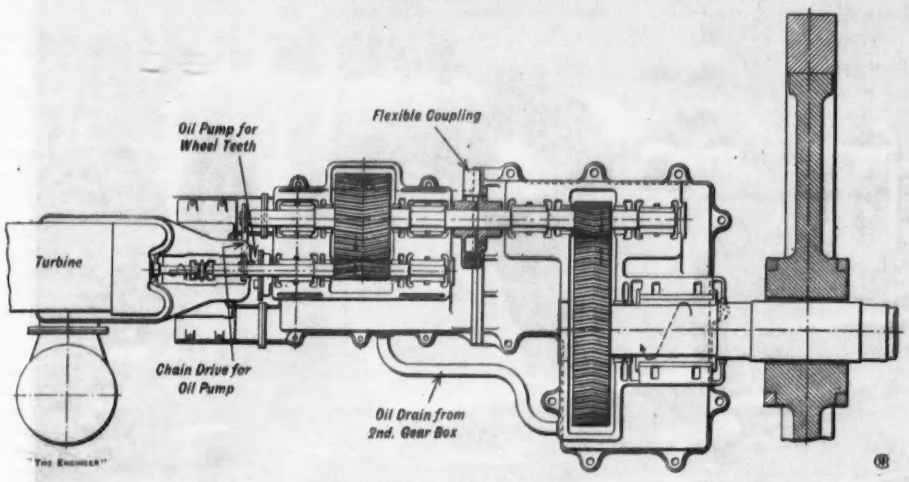


FIG. 79—LAY-OUT OF GEARING FOR ROLLING MILL DRIVE—1910

The use of gearing in connection with steam turbines was originated by Dr. de Laval in Sweden about the year 1889, who employed it with perfect success in the small single-stage impulse turbines which will always be associated with his name. In 1896 Sir Charles Parsons constructed a generating unit of 150-kW capacity for the Forth Banks Power Station, this unit consisting of a turbine running at 9600 r.p.m. and driving an alternator at half this speed by means of double helical gearing. The gears were cut in an ordinary universal milling machine and ran very well indeed, though noisily. Their efficiency, as deduced from the heat losses, was about 98 per cent. In 1897 speed reducing gear was first used for marine propulsion. A small launch, 22ft. long, was fitted with a Parsons turbine running at no less than 33,000 r.p.m. The turbine drove two propeller shafts at 1500 r.p.m. by single helical gearing. The diameter of the turbine spindle was only 2in. and the pitch diameter of the pinion no more than 0·844in. The machinery worked well and gave the launch a speed of 9 miles per hour.

For the next ten years or so, no further applications of gearing to turbines for either land or marine duties was made by Sir Charles Parsons, but towards the end of this period he carried out exhaustive experiments with the object of finding out what surface velocities could be used, and what amount of power could be transmitted by double-helical gearing consistently with safety and durability. The results were so encouraging that new possibilities were opened up for turbine machinery, both on sea and land. To put the question to a practical test at sea the Parsons Marine Steam Turbine Company purchased, in 1909, the steamer "Vespasian," a cargo vessel of 4350 tons displacement, and replaced her 750 h.p. triple-expansion engine by geared turbines. The success of the experiment has become historical. It brought about the general use of geared turbines in both mercantile and naval vessels, about 18,000,000 h.p. of gearing being employed at sea within the next ten years. The gearing of the "Vespasian" consisted of two double-helical pinions of chrome-nickel steel, each having twenty teeth on a pitch diameter of 5in., gearing into a steel-rimmed wheel of 198 teeth on a pitch diameter of 99·5in. The gear ratio was, therefore, 19·9 to 1, and at the normal propeller shaft speed of 65 r.p.m., the pitch line velocity was 28·2ft. per second. The width of the gear face was 24in., and the teeth were inclined at 20 deg. to the axis.

FIG. 81—FIRST REDUCTION GEAR AND FLEXIBLE COUPLING

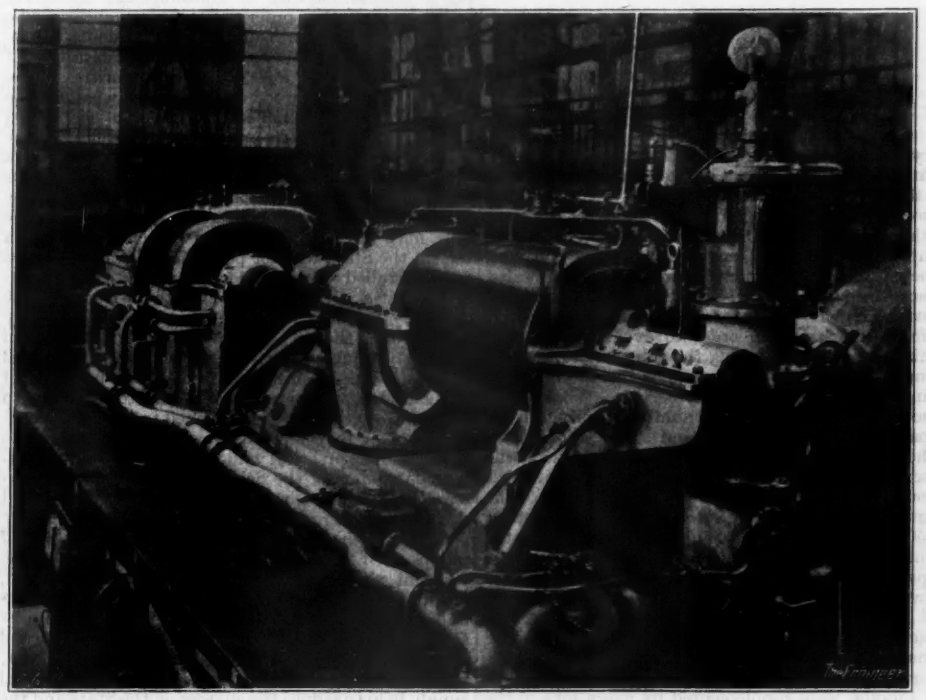
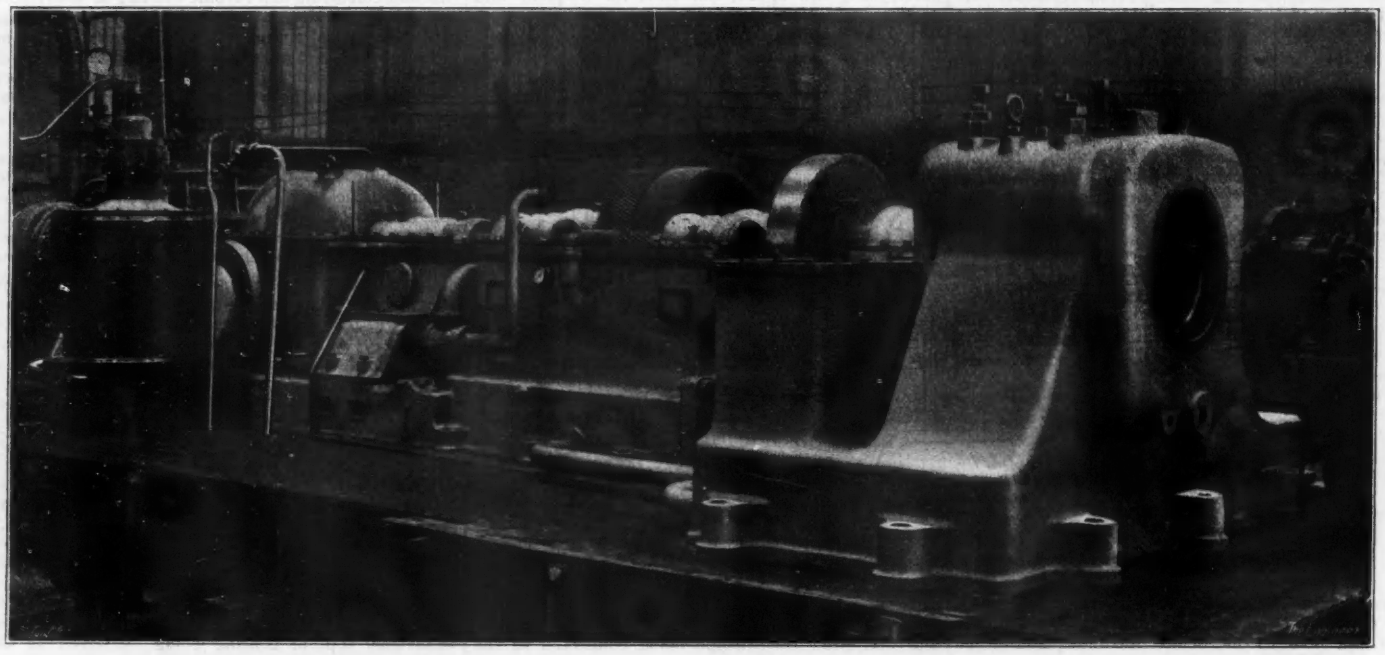


FIG. 80—750 B.H.P. MIXED PRESSURE TURBINE AND GEARS FOR ROLLING MILL DRIVE—1910

Simultaneously with the application of gearing to marine purposes, an equally bold departure was made in land practice by the use of a geared turbine to drive a rolling mill, as mentioned above. In some ways this was an even more courageous experiment, for not only was the drive a more irregular one, but the speed ratio was so great that double-reduction gear had to be used. The rolling mill was of the three-high type, with rolls 28in. diameter by 84in. long, and was used for the production of ships' plates. The original idea of the owners was to drive it electrically, generating power for the purpose by an exhaust steam turbine. It was proposed to make use of an existing heavy fly-wheel for equalising the load on the motor and generator. Then it occurred to some one that it might be possible to do away with the electrical machinery altogether, and to drive the mill from the turbine by gearing instead. As, by this plan, the transmission and conversion losses would be reduced from about 15 per cent. to less than 2 per cent., and a considerable saving in capital expenditure would also be effected, it was decided to try the experiment.

The machinery supplied by Messrs. Parsons consisted of a mixed-pressure turbine with a normal rating of 750 b.h.p. at 2000 r.p.m., and a double-reduction gear to give a final speed of 70 revolutions to the fly-wheel shaft. The turbine was designed to work with exhaust steam at an absolute pressure of 16 lb. per square inch, or with live steam at a gauge pressure of 60 lb. per square inch. Full power could be developed with steam from either source alone, or by any combination of the two kinds of steam. The turbine was a single-cylinder machine with two separate valve chests, each containing the usual runaway valve and throttle valve. Steam from

PARSONS TURBINE AND DOUBLE REDUCTION GEARING FOR ROLLING MILL DRIVE—1910



the low-pressure chest entered the cylinder at about midway of its length. The two throttle valves were operated by steam relays, so arranged that preference was given to the admission of exhaust steam so long as any of it was available. When the supply of exhaust steam was insufficient, the balance of the power required was supplied automatically by high-pressure steam. A device was fitted to cause the low-pressure throttle valve to close whenever the pressure in the exhaust steam receiver fell almost to that of the atmosphere, this being a necessary precaution to prevent air being drawn into the system.

The turbine speed of 2000 r.p.m. was first reduced to 375 revolutions by a pinion of forged chrome-nickel steel, having twenty-five teeth on a pitch diameter of 7·14in., and gearing into a wheel of 131 teeth on a pitch diameter of 37·43in. The total face width of the gear was 24in. The second reduction, from 375 to 70 revolutions, was effected by a forged mild steel pinion of twenty-three teeth on a pitch diameter of 14·91in., gearing into a 127-tooth wheel of 80·85in. pitch diameter. The total width of this gear was 16in. An inclination of 23 deg. to the axis was adopted for the teeth of both gears. A flexible coupling was fitted between the turbine and the high-speed pinion, also between the first and second reduction gear. The low-speed gear wheel was keyed directly on to the shaft carrying the fly-wheel, which was 23ft. in diameter and weighed about 90 tons. This shaft was connected to the centre roll by a pair of wobblers, one of which was of cast iron designed to break in the event of any excessive strain coming on the mill. The lay-out of the gearing is illustrated in Fig. 79. Photographs of the turbine and gears are reproduced in Fig. 80 and the engraving above, the latter showing the 22in. pedestal for the fly-wheel shaft incorporated with the second gear casing. A view of the first reduction gear and flexible coupling is given in Fig. 81.

The first slab was put through the mill on September 10th, 1910, after the plant had been run idle for a few days to allow the bearings and gears to settle down. The late Mr. A. Q. Carnegie, in describing the installation before the West of Scotland Iron and Steel Institute in 1911, said that everything went off so quietly that, although he was in the turbine-room at the time, he was not aware that rolling had commenced until the slab had made six or seven passes through the rolls. The mill was capable of rolling thirty slabs per hour, the largest size of plate produced being about 60ft. long by 6ft. wide, and of a minimum thickness of 0·13in. The power taken by the mill was calculated to reach 4000 h.p. or 5000 h.p. during heavy passes, most of this being furnished by the stored energy in the heavy fly-wheel. When rolling 13·25 cwt. slabs, 4in. thick, into plates of a thickness of 0·31in., the maximum power absorbed was 2500 h.p., of which 556 h.p. was supplied by the turbine. The plant proved a most gratifying success from the time it was started, no trouble of any kind being experienced with it.

(To be continued.)

Paris Water Supply.

THE removal of barriers around Paris profoundly modified the conditions of water supply, sanitation and other municipal services which previously had been confined to a circumscribed area. The levelling of fortifications laid Paris open to the suburbs, and a growing population spread over the communes and gave continuity to problems of water supply and sanitation throughout the Department of the Seine and a part of the Seine-et-Oise. New services were created at the Hotel de Ville four years ago to centralise the technical problems involved in providing for the requirements of a population of about 3,000,000 that appeared likely, at one time, to undergo a rapid progression. It was stated that the total water consumption in the Department of the Seine was 400,000,000 million gallons (1,800,000 cubic metres) a day, about one half of which was unfiltered water, and that the supplies would have to be doubled in thirty years. The circumstances which accounted for that growth of population disappeared with changed economic conditions and lessened the difficulties of solving what appeared to be a serious problem. The increase of consumption has now become normal, with little prospect of plans for a future water supply being upset by a rapid rise of population through exceptional causes.

Those plans are intended to ensure an adequate supply pending the completion of the Vals de Loire aqueduct, which may take anything between five and ten years. At present, a part of the supply is obtained from fifty springs within a radius of about 100 miles, the first installation dating from 1865, when the Dhuis aqueduct, bringing water from the source of the river of that name in the Department of the Aisne, was completed. Having a length of 80 miles and constructed of masonry, it has for many years revealed defects through sagging, and this has necessitated extensive repairs. The water is chlorinated on account of infiltrations, and in order to avoid further contamination when traversing the suburbs the water is pumped through cast iron pipes laid in the masonry main to the Ménilmontant reservoir. The Vanne aqueduct carries water from a number of springs in the Departments of the Yonne and Aube, those on a higher level sending supplies by gravitation, while the water from lower springs is raised to the aqueduct through collectors by three pumping stations. The length of the aqueduct is 107 miles. It supplies 23,500,000 gallons (106,000 cubic metres) a day to the Montsourie reservoir. The Avre aqueduct from the Department of the Eure has a variable delivery between 15,000,000 and 22,000,000 gallons (70,000 and 100,000 cubic metres) a day to the Saint-Cloud reservoir. Another aqueduct from the Loing and Lunain, near Nemours, to supply the Montsouris reservoir, was completed in 1900. From that time the supplies were supplemented by extensions of the St. Maur filtering beds and the creation of new ones at Ivry, but after the war it became urgent to obtain additional spring water, and creditable work was accomplished in 1923 and 1924, when the sources of the Voulzie, Durteint and Dragon were utilised by the construction of a pressure main connecting with the Loing aqueduct. Special precautions had to be taken to prevent the hammering effect produced by changes in the flow of water reaching a volume of 22,000,000 gallons (100,000 cubic metres) a day, and this risk was attenuated by electrically and hydraulically controlled valves, the latter actuated by a turbine, itself actuated by the flow of water in the main. Another feature of this undertaking was the necessity of returning to the Seine, for the convenience of local users, a volume of water equal to that drawn from the sources of the Voulzie, Durteint, and Dragon, for which purpose water is pumped back from a point lower down the Seine. The total length of the five aqueducts is 383 miles. They have a total capacity of 126,000,000 gallons (570,000 cubic metres) and the daily supply is 97,000,000 gallons (440,000 cubic metres).

This supply of spring water is supplemented by a possible 144,000,000 gallons of river water from the filtering beds of St.-Maur and Ivry. The present maximum daily consumption of filtered water is 88,800,000 gallons (400,000 cubic metres) and an equal amount of spring water, making 177,600,000 gallons (800,000 cubic metres), but in view of the increasing consumption per head of population, resulting largely from the modern equipment of flats, adequate provision must be made for the period occupied by the construction of the Vals de Loire aqueduct. While the existing supplies leave a fair margin for a normal increase of consumption, additional water is required in order to meet emergencies. The capacity of the St.-Maur filtering beds is to be increased by an extension for the rapid filtration of water less heavily charged with impurities. The volume of water filtered is limited by what can be raised from the Seine and Narne and the Ourcq Canal, but as the rivers are drawn on heavily for raw water there are times when their level may fall to a point that hinders navigation. The existing pumps raise a volume of water from the Seine equal to a flow of 4500 gallons (20 cubic metres) a second, and as the flow may fall to 7800 gallons (35 cubic metres) a second the State will not permit of additional pumps being installed unless the normal volume can be maintained by a diversion of water to it from outside sources. The construction of reservoirs to be fed by tributaries in the hilly district of the Morvan had been held up by doubts as to their efficiency for the original purpose of minimising the risk of floods, but a belief in their effectiveness as a means of restoring water to the Seine at critical periods seemed to justify the construction of four reservoirs, which would serve to determine the practical value of this system of regulating the volume of the Seine preparatory to the construction of other similar reservoirs if it were found desirable to increase still further the supply in dry seasons with the object of avoiding installing additional pumps. Of the four reservoirs, the two smaller, the Crescent and Bois de Chaumaçon, are completed, and the total quantity of 28,400 million gallons (128 million cubic metres) impounded by this group of four reservoirs is expected to increase the normal water level of the Seine in dry seasons by 50 per cent. Concessions to private companies for hydro-electrical supply help to reduce the charges on the State and the Paris Municipal Council. As the future Paris water

supply is now well assured the technical services attach little importance to this method of obtaining additional water from the Seine.

The filtered water is sterilised by chlorination, except 2,000,000 gallons (9000 cubic metres) which have been treated by an ozone plant installed at St. Maur in 1911, but that plant is being dismantled, and will be replaced by one capable of dealing with 66,000,000 gallons (300,000 cubic metres) a day; that is to say, nearly one-half of the total quantity of filtered water. This work is being undertaken by the Société des Eaux et de l'Ozone. The efficiency of the ozone treatment has never been called into question, and its advantages in avoiding the after taste that cannot always be entirely eliminated with chemical sterilisation is recognised, but it had to meet objections on the ground of high installation cost which involved much heavier capital charges than was the case with chemical processes. The cost of working the ozone plant has been reduced by various improvements, notably the recuperation of ozone, and at St. Maur economies are realised by cheap electricity supplied by the sanitary services, such as that provided by refuse incineration plants. Sanitation and water supply are in the hands of the same technical services. The Société des Eaux et de l'Ozone claims that the automaticity of the plant dispenses with technical control and labour, so that, apart from amortisation and maintenance charges, the cost is represented by little more than a consumption of 20 watts per cubic metre of water under the least favourable conditions. An ozone plant is in use by the London Metropolitan Water Board for whom, we are informed, plans are being prepared for an installation to treat 200 million gallons a day.

As nearly all the available springs are utilised and the filtering of water from rivers with a variable and often large content of organic matter is a makeshift that has already reached the limit of supply, the only practical means of ensuring sufficient water for the requirements of an extended Paris district was to bring supplies from the vast natural filtering bed that extends for about 60 miles in the Vals de Loire between Gien and Nevers. Through this valley the Loire flows on one side of a bed of fine sand from 20ft. to 26ft. deep, and is banked to prevent the river from overflowing. The river water is clear, and, after filtering through to the subterranean supply, it is perfectly free from bacteria. The idea of utilising that supply is more than two centuries old. It began to take definite form in 1870 when it was incorporated in a scheme of Monsieur Belgrand, the creator of the modern water supply system in Paris, but it was abandoned on the outbreak of the war in that year, and after other attempts to put the scheme in hand had failed through the opposition of water users in the Vals de Loire, the Paris Municipality initiated a long series of experiments in 1912 with a view to removing fears of a possible lowering of the subterranean water level by the withdrawal of more than 200 million gallons of water a day. Those experimepts were resumed in 1920, when forty wells were sunk and pumping was carried on for a couple of years without the water level showing any appreciable variation. A commission of experts investigated the conditions under which it was proposed to obtain this supply from the Vals de Loire, and to construct a reservoir for the storage of water when the Loire was in flood, and to return it to the river during periods of drought. Its favourable report was the determining factor in obtaining from Parliament a declaration that the scheme was one of public utility, which means that the Paris Municipal Council was invested with powers to carry out the scheme in face of an uncompromising local opposition. The Municipal Council finally adopted the Vals de Loire project at the end of 1931.

The part of the valley from which water will be drawn has a length of 25 miles between Châtillon-sur-Loire, near Briare, and La Charité. A double collector of porous concrete will be laid on the left side of the river at a depth of about 20ft. Horizontal porous concrete feeders will drain water into the collector outside a zone of 330ft. from the river bed. From Châtillon-sur-Loire to Paris the distance is about 87 miles, with a difference of level of 72ft. The topography of the country will, nevertheless, involve a good deal of trenching, tunnelling, and viaduct construction, for the first 65 miles, where the water will flow by gravitation, in a main 14ft. 9in. inside diameter, except where syphons have to be installed with two pipes of 9ft. 10in. diameter. From that point pressure mains of this diameter will be laid over uneven country to two reservoirs of 178,000,000 and 44,000,000 gallons (800,000 and 200,000 cubic metres) capacity respectively at the south of Paris. Two principal mains from the reservoirs will be carried round each side of Paris, and secondary mains will connect up the supply with the general distribution system which covers the Departments of the Seine and partly of Seine-et-Oise. The barrage reservoir, which will return water to the Loire when required, will be created at Villarest, above Roanne. The dam across the valley will have a height of 164ft., a thickness of 157ft. at the base, and 26ft. at the top. A hydro-electric plant will be installed capable of producing an average of 17,000 kW. The total cost of the enterprise is estimated at 2500 million francs, including 1000 millions to be spent on the aqueduct.

The Vals de Loire supply will be entirely in the hands of the Syndicat Général pour l'Alimentation en Eau de la Région Parisienne, which has been constituted with all the communes benefiting from the supply. The Prefect of the Seine is President of the Syndicate. It will finance the whole enterprise and will distribute water under concession from the Paris Municipal Council, which will be paid a percentage of the reciepts in the same way as is done by other public service concessions, notably gas, surface transport, and the Metropolitan Railway. Having completed arrangements with the communes, the Syndicate has been authorised by the Conseil d'Etat to issue a public loan guaranteed by the Paris Municipality. It now appears certain that work upon the Vals de Loire enterprise will be started in the course of the present year. The technical services affirm that the aqueduct will ensure an ample supply of water in the Departments of the Seine and Seine-et-Oise for at least fifty years.

A Reflection Meter and its Application.

By W. P. DIGBY.

No. I.

THE tarnishing of silver is possibly the earliest memory many of us have of the discolouration of metals. In the dietetics of childhood the blackening of the silver spoon with which we ate a boiled egg probably caused many of us to ask "Why?" Later, for those whose boyhood preceded the age of stainless cutlery and chromium plating, there came the realisation of the action of certain foods on the blades of table knives. Still later, for the same generation, came the realisation that an atmosphere of gaseous chlorine involved, as a side issue, extra trouble in cleaning buttons on tunics. Finally, in the writer's experience, was the occasion when silver coins in his pockets became blackened by sulphur fumes in a factory in which certain processes were being carried out.

Among the recreations of recent years, many will confess to finding an absorbing interest in comparing the rates of tarnishing or of corrosion of various different metals under the same conditions (whether the cause is gaseous or liquid is not at the moment material) or on the same metal or alloy in media of different composition or in varying concentrations.

These are all commonplace subjects. For years chemists and physicists have exposed selected metals or selected alloys to corrosive action, and chronicled the loss of weight by various means from chemical analyses to the photographing of notorious examples of wastage. But the estimation by analytical means when the films are of microscopic thickness is slow and complicated. When in place of films we are considering relatively thick deposits of oxides, sulphides, or chlorides, chemical analysis is the final and quick Court of Appeal, but the time spent in waiting for the relatively thick deposit is sometimes long and may be compared to the time lost in the preliminaries of a case being heard in the High Court.

As an alternative to patient waiting, where the effect of immersing ferrous or cuprous alloys in corrosive liquid media has to be compared, observations of the colour changes in the media are often a sufficient index of the relative resistances of a number of alloys. In other cases the amount of dissolved metal has to be determined by the chemist.

Mindful of the commonplace happenings mentioned, the writer came to the conclusion that photometric records of the loss of the reflecting power of polished metals or of the change in the surface of paints would be likely to enable him to compare:—

(*a*) The behaviour of a group of metals exposed to attack in the same corrosive medium, whether gaseous or liquid;

(*b*) The relative intensity of action upon the same metal of corrosive media of varying composition;

(*c*) The colour permanence of paints used in the protection of materials.

From these it was expected that it would be possible to compare the corrosive properties of the atmosphere in and near industrial centres, to compare one area with another, and to correlate the direction and velocity of winds passing over industrial areas with the amount of pollution in the area.

The estimation of the degree of attack by the atmosphere on polished metal plates of tin and tin alloys has been investigated by Messrs. Kenworthy and Waldram in their paper No. 669, read in September, 1934, before the Institute of Metals. The circulation of this paper followed very closely upon some interesting preliminary work along a parallel line by the present writer. Initially, there had been an almost identical approach to the problem. The writer decided in 1931 to begin as Messrs. Kenworthy and Waldram did, by deciding to use a photometer as the means of measuring the loss of reflecting power, but at Colonel Edgcumbe's instigation the writer used the photo-electric cell as his means of measurement.

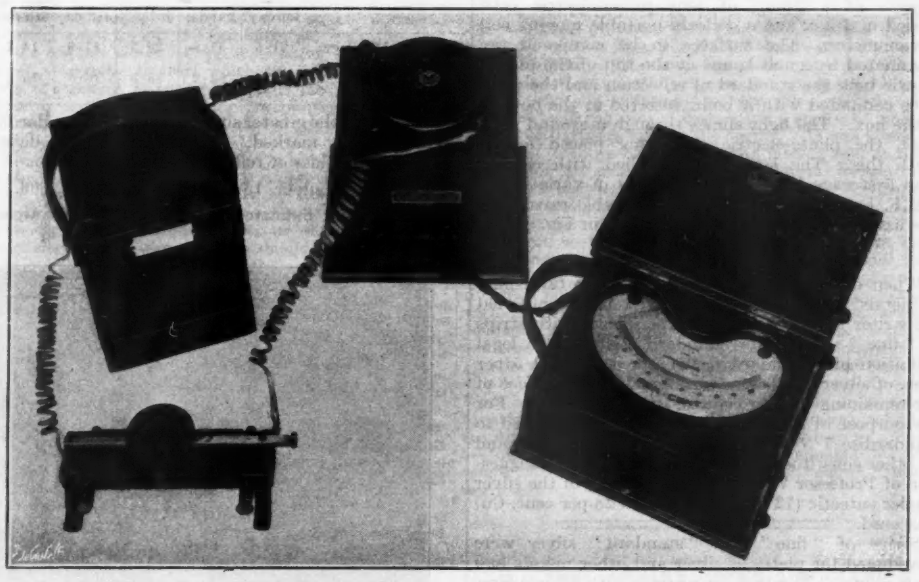
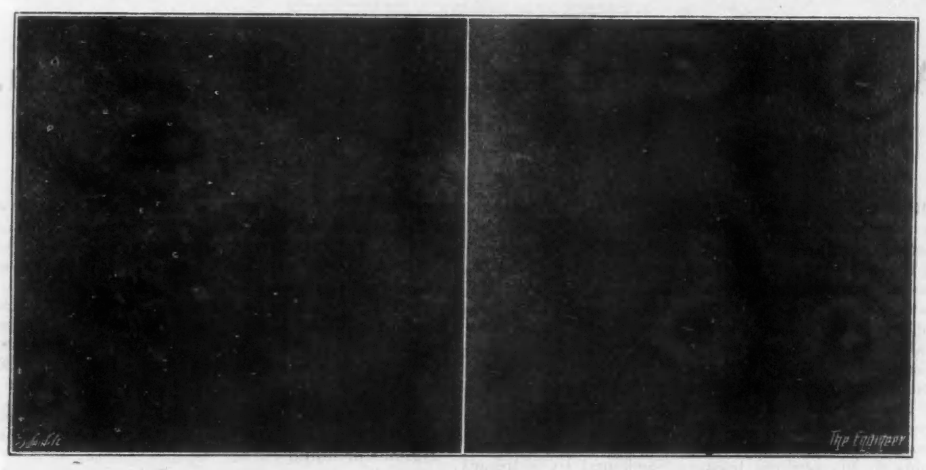


FIG. 1—PHOTO-ELECTRIC REFLECTION METER

TABLE I.—*500 Hours' Continuous Exposure, March 17th to April 7th*, 1934.

Material.	Where exposed.	Terminal reflecting power as percentage of initial value.	Percentage loss of reflecting power over period.	Percentage loss of reflecting power per day.	Final appearance.
"Standard" silver	West Hartlepool	16·7	83·3	3·99	Predominant colour yellow with blue, mauve and pink sub-areas
Ditto	Westminster	10·5	89·5	4·25	Predominant colour blue with pink, mauve and blue sub-areas
"Fine" silver	West Hartlepool	29·6	70·6	3·35	Predominant colour light yellow with very few small blue sub-areas
Ditto	Westminster	18·0	82·0	3·90	Predominant colour irregular grey brown with small iridescent peacock blue areas

At once the value of this variant over that of the more orthodox method was apparent. It not only gave easy comparisons of the variation in the rate of tarnishing in different districts, but indicated markedly different results at different windows in the same house during the same period. It also permitted comparisons to be made of the colour changes and loss of reflecting power of some pigments after immersion in water or after exposure to ultra violet light or to sunlight. It has also been possible to study the recovery phenomena in which part of the loss due to the exposure to ultra violet light or to the immersion in water is regained.



FIGS. 2 AND 3—TARNISHING OF "STANDARD" SILVER PLATES IN 120 HOURS

DESCRIPTION OF THE APPARATUS.

For the purpose of taking these tests the apparatus consists of a group of four photo-electric cells carried in a box and a delicate portable moving coil galvanometer. The surfaces to be compared are illuminated by small lamps at the top of the photo-electric box, the standard of reflection and the plate to be compared with it being inserted at the bottom of the box. The light shines through a ground glass plate, the photo-electric cell being placed underneath this. The lamps are supplied with current from a storage battery, adjustments in variation in E.M.F. being corrected by an adjustable resistance. The assembled apparatus is illustrated in Fig. 1.

MATERIALS USED.

When estimating the relative rates of tarnishing of metals in the atmosphere, past reminiscences led the writer to make his first experiments with strips of "fine" silver and "standard" silver (the legal definition of "standard" silver prescribes 92·5 per cent. of silver and leaves to the makers the choice of the remaining 7·5 per cent. of its composition). For the purpose of these investigations it was decided to standardise 7·5 per cent. of electrolytic copper and no other constituent. At a later date, on the suggestion of Professor W. H. Merritt, an alloy of the silver copper eutectic (72 per cent. Ag and 28 per cent. Cu) was used.

Strips of "fine" and "standard" silver were abandoned for plates of silver and other metals and their alloys. The first set of tests with silver plates having a standard size of 90 mm. by 90 mm., covered a period of 500 hours.

COMPARATIVE RATES OF TARNISHING.

One "fine" and one "standard" silver plate were exposed on a window sill facing east on a third floor in Westminster, and two similar plates on a window sill facing N.N.E. on a second floor at West Hartlepool, about 2 miles north-west of some large steel works. Initially, the basis of comparison was the reflection of a polished "standard" silver plate which was measured and reckoned as 100. Later white blotting paper was used as the reference standard.

TABLE II.—120 *Hours' Exposure, April 19th to 24th*, 1934.

Material.	Exposure facing.	Terminal reflecting power as percentage of initial value.	Percentage loss of reflecting power over period.	Percentage loss of reflecting power per day.
"Standard" silver	West	42·1	57·9	11·58
,,	South	52·0	48·0	9·6
,,	East	44·3	53·7	10·74
"Fine" silver	West	92·0	8·0	1·6
,,	South	100·0	nil	nil (dubious)
,,	East	97·5	2·5	0·5

In each case—Table I—the "fine" silver was less severely attacked than the "standard" silver, and in each case the action at Westminster was more severe than at West Hartlepool. In each case all deposits of soot and dust were washed off before measuring the loss of reflecting power.

Another test of shorter duration was carried out on the sills of three first-floor windows at a house at Fairhaven, near Lytham-St. Anne's, Lancashire. Fairhaven is a seaside residential suburb, about 10 miles from the chimneys of the North Lancashire cotton mills.

In each case—Table II—the greatest action was noticed on the west side, but the action was found to be much greater with "standard" than with "fine" silver.

An estimate was then made of the daily loss of reflecting power of "fine" and "standard" silver plates at Westminster, again facing east.

TABLE III.—120 *Hours' Exposure, from April 30th*, 1934.

	Percentage of initial reflecting value retained at end of				
	1st day.	2nd day	3rd day	4th day	5th day
"Standard" silver	91·5	57·8	29·5	17·9	14·7
"Fine" silver	100	83·2 ?	85·5	76·5	75·2

Here, again, the greater susceptibility of "standard" silver is clearly marked. Taken over the five days, the percentage loss of reflecting power per day is :—

"Standard" silver, 15·06 ; "fine" silver, 2·96.

These results indicate that for any except areas remote from any source of atmospheric pollution, the 500 hours' period was far too long, and that for Westminster early in May 120 hours, embracing ordinary week-days, is perhaps too long. Fig. 2 is from a photograph of the "standard" silver plate (No. A3) used in this test. A further test of 120 hours' duration from July 26th to 31st on the same window sill was made. "Fine" and "standard" silver, as well as the "silver-copper eutectic" plates were exposed. In this case day-to-day readings were not taken, but at the end of the period the reflection was first measured with the adherent dust and soot and then after rinsing this off. Fig. 3 is from a photograph of the "standard" silver (plate No. A6) at the end of this test.

The percentage loss of reflecting power per day was as follows :—

TABLE IV.

	With adherent dust.	After washing.
"Standard" silver	5·0	4·6
"Fine" silver	7·4	3·2
Silver-copper eutectic	6·8	4·4

Wind eddies and rain eddies probably account for the differences in the first column. It will be noted from the second column that while the attack on the "fine" silver agrees with Table III, the action on the "standard" silver, while greater than on the "fine" silver, has a lower marginal difference. The "standard" and "fine" silver plates had only a dull surface, with numerous tiny pin-point spots. The eutectic plate was also spotted, but the background was yellow with larger blotches of an orange-yellow colour.

Plates Exposed at Dunbar, from July 23rd, 1934.

	Loss of reflection after 5 days. Per cent.
"Standard" silver	14
"Fine" silver	22
Silver-copper eutectic	8

All plates slightly marked by rain drops. The "standard" and "fine" silver plates have pronounced discolouration. It was surprising that the "fine" silver showed most loss of reflecting power.

Silver-Copper Eutectic Plates Exposed at Fairhaven, Lancs., from July 23rd, to July 28th, 1934.

All plates tarnished yellowish in colour with small brown spots, possibly due to soot.

Plate exposed on the—	
East side	Shows least discolouration and 37 per cent. loss in reflecting power
South side	Has irregular yellow to yellow-green areas and 39 per cent. loss in reflecting power
West side	Slight brownish tinge to yellow ; rain marks very distinct ; loss in reflecting power, 48 per cent.

TABLE V.—*Plates Exposed on Office Window, Westminster, for Twenty-eight Days from July 26th*, 1934.

	Loss of reflection value.			
	Measurements taken on July 31st (5 days later).		Measurements taken at conclusion of 28 days.	
	In dusty condition.	After washing.	In dusty condition.	After washing.
"Fine" silver	Per cent. 25	Per cent. 23	Per cent. 54	Per cent. 44
"Standard" silver	37	16	83	50·3
Silver-copper eutectic	34	12	66·6	60·8

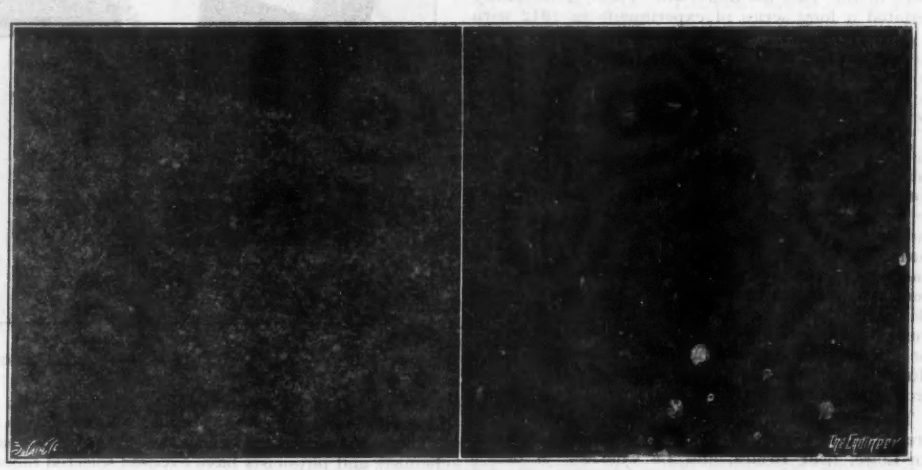
In appearance the "fine" silver plate had a grey tarnish with minute dust specks, and a general grey colour.

The "standard" silver was a darker grey, the specks due to soot being more pronounced.

The "silver-copper eutectic" plate was yellowish brown in colour with large orange-coloured blotches, particularly at the bottom of the plate.

Plates Exposed at Middleton-in-Teesdale from June 23rd to September 16th, Two Silver Plates ; from July 7th to September 16th, Ag Cu Eutectic.

Middleton-in-Teesdale is a village on the eastern slopes of the Pennines, about 60 miles west of the coast.



FIGS. 4 AND 5—TARNISHING OF SILVER-COPPER EUTECTIC PLATES

These were all measured unwashed, but free from any adherent dust.

	Loss of reflection value. Per cent.
"Fine" silver	50·8
"Standard" silver	43·7
Silver-copper eutectic	38·2

These were all deeply marked ; the "fine" silver with brownish patches, the "standard" silver with larger dark grey patches, on a yellowish brown background, and the silver-copper eutectic with a greenish yellow background with green and grey blotches.

All showed a number of spots suggestive of soot, possibly from the chimneys in the cottages comprising the village.

Simultaneously with these a silver-copper eutectic plate, No. C 2, was exposed in West Hartlepool, and suffered a loss of 61·2 per cent. of its reflecting value. The characteristics are a large number of soot spots on a yellowish green background with iridescent areas pink, blue, and green in colour. Photograph Fig. 4 depicts this plate.

Plates Exposed at West Hartlepool from June 27th to August 3rd, 1934.

"Fine" silver plate mottled grey and purple colour with a few soot marks.

"Standard" silver—predominant colour grey—small blue areas and a few dust spots.

	Loss of reflection value, per cent.
"Fine" silver	66·3
"Standard" silver	64

Plates Exposed at a House Outside Wolverhampton at a Height of 530ft. from July 12th to July 17th, 1934 (120 Hours).

"Silver copper eutectic" plates:

Facing north	Many rain marks, tarnishing very slight; 15 per cent. loss of reflecting power
Facing east	Fewer rain marks, one or two small blotches; 10 per cent. loss of reflecting power
Facing south	Blotches chiefly large rain marks; 15 per cent. loss of reflecting power
Facing west	Large number of small rain spots; 6 per cent. loss of reflecting power

None showed any marked discolouration.

Plates Exposed at House in Wolverhampton from July 12th to 18th, 1934 (135 Hours).

Silver-copper eutectic plates facing east and west. Neither showed any marked discolouration other than the effect of rain drops and soot.

The prevailing winds were mostly north and west. The plate facing east lost 5 per cent. of its reflecting power, and that facing west 14 per cent.

Plates Exposed at Bigbury, Devonshire, from August 20th to 25th, 1934 (120 Hours).

"Silver-copper eutectic" plate facing sea, colour yellow, pink, and dark brown, much rain during period of exposure, reverse side where plate had been resting against the iron of the guttering of the house shows a copper chloride deposit. The loss of reflecting power was 65 per cent.

An identical plate exposed on the side of the house remote from the sea shows blotched brownish discolouration, with a loss of reflecting power of 76 per cent.

TESTS AT RICHMOND HILL, SURREY.

A 500 hours' exposure on a balcony facing north-east at Richmond, Surrey, may be compared with one of 600 hours' duration on a window sill facing south-west, both tests ending on August 14th, 1934:

Percentage Loss of Reflecting Power per 100 Hours.

	500 hours facing N.E.	600 hours facing S.W.
"Fine" silver	6·4	6·1
"Standard" silver	9·0	6·76
Silver copper eutectic	8·6	8·4

A photograph of the silver copper eutectic plate from the north-east window is reproduced (Fig. 5).

The following notes were made of the appearance of the plates:—

"Fine" silver	500 hours N.E.	General brown colour, rain drops hardly preceptible
	600 hours S.W.	Blotched, yellowish, very distinct rain drops
"Standard" silver	500 hours N.E.	Very faint marking, rain drops just perceptible
	600 hours S.W.	Very slight general tarnishing, most marked at bottom of plate; small rain marks
"Silver copper eutectic"	500 hours N.E.	Yellow marking at rain drops; discolouration most marked at bottom (Plate No. C 7, Fig. 5)
	600 hours S.W.	Yellow colour, very distinct rain marks; a few bluish patches

(To be continued.)

INSTITUTE OF MARINE ENGINEERS.

THE thirty-ninth annual dinner of the Institute of Marine Engineers, which took place on Friday evening, February 22nd, at the Connaught Rooms, was attended by about 700 members and guests, which number reflected the growth of the Institute's activities and the promise of a revival in the marine engineering industry. The chair was taken by Mr. John H. Silley, the President of the Institute, and the toast of "The Shipbuilding and Engineering Industries" was happily entrusted to the Rt. Hon. Lord Essendon. In his speech, Lord Essendon congratulated Mr. John Silley on his good recovery from his recent illness. Speaking on the outlook for shipbuilding and marine engineering, Lord Essendon gave it as his opinion that the technical knowledge of British firms gave the shipowner the best ships and engines and the utmost value in price. Some years ago, he, Lord Essendon, had expressed the view that the oil engine would supersede the steam turbine. To-day, he saw that with the improvements in boilers, turbines, and auxiliaries, steam was moving forward, and steam could move the oil engine. The problem of subsidies was a real one and was reflected in the fact that the cost of the French liner "Normandie" would be about £9,000,000, or nearly double, he thought, the probable cost of the "Queen Mary." Lord Weir, who replied, said that to-day coal was as good as oil as a marine fuel. Oil was admittedly easy, and coal difficult to use to the fullest technical and thermal advantage; but he anticipated that new devices and systems would alter that position. The toast of "The Dominions and the Mercantile Marine" was proposed in a charming way by Sir Robert Horne, and Sir Hal Colebatch replied. Sir William C. Currie gave the toast of "The President," and in his reply Mr. John Silley referred to his own early days with the late Mr. John Carry, and the striking development in the membership and scope of the Institute's activities during recent years. The evening was a most enjoyable one in every way.

Private Plants and Public Supply Tariffs.

IN a paper on "Private Plants and Public Supply Tariffs," read by Mr. J. A. Sumner before the Institution of Electrical Engineers, a comparison is made of the cost of power production for normal requirements up to 500 kW. The results of an investigation into private plant costs in an area of a semi-rural supply undertaking are followed by a more generalised study of the cost of running oil engines and pass-out turbines, which have been found to be the most efficient forms of power plant. An analysis of the cost of providing electricity from public supply undertakings in the same area as that in which private plant investigations were conducted, is then made, and the technical design, progress, and costs are detailed for the scheme. Private plant and public supply costs are then compared for this particular case. Finally, a brief classification is made of the various types of supply undertakings and the generalised costs for private plants are compared with the general case for the public supply.

The conclusions reached are: (1) An efficient public supply undertaking can supply untransformed H.T. power at a less cost than that at which the power can be generated by any modern form of prime mover installed on the consumers' premises; the public supply cost is also more likely to decrease in the future. An exception may arise if a factory requires steam primarily for process work, and secondarily for power production, and if the process requirements are coincident in time. (2) The averaged public supply tariff which will enable power to be obtained as economically (at high tention) as it could be generated by means of an oil engine, is estimated to be £4·95 per kW of maximum demand (thirty-minute average) and 0·4d. per unit for large plant, rising to £6·6 per kW of maximum demand+0·53d. per unit where smaller plant is intalled. (3) The cost of power generated at small residential plants exceeds the cost at which power is available from an efficient and modern public supply undertaking.

The author has found that in a large number of instances there is a belief that electricity can be obtained from privately installed oil-engine plant at ½d. per kWh, but so far he has not found an actual instance where generation is being carried out at this figure when all the real cost components are taken into account. From the point of view of the electricity supply industry, the real cost of private plant running should be openly discussed and the broad limits of cost should be published. In many cases supply undertakings are being induced, by the implied threat of the installation of oil engines, to sell electricity at costs which are far below the real costs of running private plant, and the domestic consumer is not always receiving his proper quota of the reduced costs which ensue by virtue of the power load that is available.

The increase in sales of current which is so necessary to the success of the electricity supply industry is not to be obtained, however, merely by the demonstration that the public supply can provide the cheapest form of energy; it is necessary to ensure that a reasonable national standardisation of tariffs should be made.

It is suggested, firstly, that the capital expenditure required to give supply to a consumer is the same for all types of areas of equal development. As there is no great difference between areas in the characteristics of the domestic and general L.T. demands, the cost of giving supply should, therefore, depend only upon the stage of development of the undertaking and, to a far less degree, upon the nature of the system load. The effect of obtaining a power load is, however, to improve the load characteristics of the undertaking and to reduce the average price at which electricity can be sold, and it is reasonable to expect that urban undertakings, which generally have a large power demand, will have lower charges for all purposes than rural undertakings, where the power load does not usually occur. It is not found that this relation exists between increased power output and reduced charges to the domestic consumers.

A study of the tariffs which prevail throughout the country shows that many undertakings are selling electricity for power purposes at a lower rate than is required to compete with the real costs of running private plant, and in most of these cases the domestic consumers are not receiving the benefit of the reduced tariffs which are justified because of the reduction in overall costs brought about by the power load.

The author is definitely of the opinion that it would be financially possible to achieve an approach to one tariff, common to all undertakings throughout the country, provided some co-ordination were obtained between undertakings. It is considered that the effect of the power load is to reduce the cost at which electricity can be sold, and any consideration of the merging of supply areas should have this feature in view. By merging areas in this way it is probable that the cost per unit supplied by any undertaking would not exceed 1d., and in many cases would be as low as 0·7d. Is it not possible that the method of charging of the future may involve a return to the "flat rate" and that all consumers, both power and domestic, may be charged at one basic price, with reductions for off-peak loads, &c. *i.e.*, the average cost to the undertaking, per unit supply for all purposes? In the author's view, in all cases of power consumption except the very special ones, it would be found economical for the consumer to pay up to 1d. per kWh, and it is beyond question that the domestic consumption would be greatly stimulated if a flat rate below 1d. per kWh were available for all domestic consumption.

After a careful effort is made to study the manner in which an improvement in diversity or system load factor can cause reductions in tariffs, it does not seem unreasonable to forecast that electricity will be available within the next few years to all consumers at a rate of 0·5d. per unit.

A further inference which can be made as a result of the analyses is that the merging of electricity areas into much larger single districts than at present is necessary for reasonable standardisation of tariffs. In this way the inevitable deficit of a newly developed area can be balanced against the surplus from the older areas and a uniform tariff can be kept throughout the single large administrative district. It is only by this means that the present "see-saw" effect in tariffs can be eliminated.

It can hardly be disputed that one of the most serious hindrances to the proper development of the public supply is the extraordinary inequality of the charges made for electricity in different but contiguous electricity areas. It is contended that the most urgent need in the electricity supply industry is that of deciding upon the basis of the standard tariff to be adopted, and then for this tariff to be adopted at once by all undertakings, so that each consumer throughout the country shall pay on exactly the same basis. The author ventures to put forward the opinion that if this step were taken and suitable publicity given, the result would be immediately noticeable in a large increase in the sales of electricity and in the number of connected consumers.

SIXTY YEARS AGO.

IT was better known on this side of the Atlantic than on the other, so we said in a leading article in our issue of February 26th 1875, that the United States really had no navy to speak of at the moment. The country and the Government were apathetic on the subject in spite of the efforts made by naval officers to bring home to them the necessity for placing the nation's naval forces on a satisfactory basis. A report submitted by Admiral Porter to the Secretary of the U.S. Navy provided us with an occasion for discussing the subject. Admiral Porter maintained that America could not look idly on while other countries, particularly Germany, were adding rapidly to their naval strength. Sooner or later, we said, it was evident that the United States would provide itself with something more than a merely nominal navy. With its great wealth and the advantage which it would possess in starting with the accumulated experience of other countries at its disposal, America, we suggested, might soon have a navy superior in offensive and defensive power to any other in existence. It was possible, however, that the adherence of American shipbuilders and artillerists to their old prejudices and the characteristic disinclination of the nation at large to admit that anything upon which they had spent talent, time and money was not very good indeed, might act to prevent full advantage of the situation being taken. There was evidence to that end in Admiral Porter's own report. For years the belief had prevailed that guns of unexampled power could be made of cast iron, of the excellent cast iron of which the United States was so proud. Admiral Porter contended that smooth-bore cast iron guns were highly satisfactory but admitted that for rifled weapons the material had been proved useless and a source of greater danger to the users than to the enemy. He was however unwilling to go over wholly to rifled guns of iron or steel of the built-up pattern such as other naval powers had adopted almost exclusively. He argued that the United States Navy ought to be equipped with a mixed armament of smooth-bore cast iron guns and rifled weapons. This suggestion, we thought, was as prudent as would be one for arming a portion of the United States Army with old smooth-bore muskets. Doubtlessly, the suggestion if carried out would give great satisfaction to any nation with which the United States might come into armed conflict. On the subject of torpedoes the Admiral expressed himself strongly in favour of the "outrigger" type in which an explosive charge was carried at the end of a long rod projecting from the attacking vessel. The Whitehead or "fish" type of self-propelling underwater torpedo was at that date being rapidly developed but the Admiral it will be noted preferred to adhere to a form of torpedo attack which had been originated by his countryman, Robert Fulton, nearly eighty years previously.

THE DIESEL ENGINE USERS ASSOCIATION.

AT the Diesel Engine Users Association annual informal dinner, which was held at Pagani's Restaurant, Great Portland-street, on Tuesday evening, February 26th, over ninety members and guests were present, and a very enjoyable evening was spent. The chair was taken by Mr. A. E. Cornewall-Walker, M.I. Mech. E., the President, and the toast of "The Association" was admirably proposed by Dr. Herbert Levinstein, M.Sc., F.I.C., the President of the Institution of Chemical Engineers. In his speech, Dr. Levinstein referred, as a power user, to the relatively high cost of electric power in England, which, he said, kept back from this country new electro-chemical processes, which had made their way in countries where power was cheaper. In the past, he said, coal had given us cheap power. Could not, he asked, the problem of burning solid coal in the cylinder of an internal combustion engine be tackled in real earnest? The more scientific use of home fuel supplies along these lines opened a field for British capital and brains, which should not be neglected. Dr. Levinstein further said that he thought that the time was now ripe for another great invention in prime movers. When would it be possible, he asked, for the scientist and the engineer to separate by some method the inert nitrogen from the active oxygen in the air so as to avoid wasting about four-fifths of the charge taken in? In replying to the toast, Colonel A. E. Davidson, President of the Institution of Mechanical Engineers, and a member of the Association for over a decade, paid a high tribute to the work done by the Diesel Engine Users Association. Its membership was steadily increasing. It had begun with power station work and had embraced pumping plants, and its annual running costs were invaluable to the industry. Could the Association take full advantage of the Diesel engine developments at sea, and for road and air transport its future was assured. The toast of "Our Guests" was well left in the able hands of Mr. D. R. Pye, and the President briefly replied and presented the "Percy Still" Medal to Eng.-Rear Admiral J. Hope Harrison for his paper on "Cylinder Liner Wear."

Progress on the Boulder Dam.

No. IV.

(*Concluded from page 197, February 22nd.*)

Intake Towers and Spillways.

SINCE we dealt with the Boulder Dam a year ago the four great intake towers have been reared and to-day are nearing their structural completion. Similarly, the two spillways—one on each flank of Black Canyon—have been advanced far enough to take in hand the erection of their gates. The four intake towers—see page 226—are of reinforced concrete and each tower has an overall diameter of 82ft. at its base and is about 64ft. in diameter at the top. The intake towers are upstream of the dam, two on the Arizona side and two on the Nevada side of the canyon, and extensive excavating of the canyon walls was necessary to provide the prescribed foundation and recesses for these structures. All four intake towers are alike in design and rise from a foundation elevation 388ft. higher than the lowest point of the dam. The total height to the top of the gate operating house is 380ft. Each tower houses two 32ft. diameter cylindrical gates, one at the base and the other 150ft. higher, which will control the flow of water to the power penstock tunnels or to the outlet valves to be located downstream of the power-house. The towers have been designed to withstand seismic disturbances, and to this end each is constructed of 6500 tons of steel bars embedded in 21,000 cubic yards of concrete. The two spillways, which connect with two of the diversion tunnels, and which required the excavating of 700,000 cubic yards, were designed only after much laboratory research in America with models on 1 : 20 scale, and each spillway is capable of disposing of 200,000 cubic feet of water per second. The open section of each spillway is about 650ft. long and the water will fall into a side channel 150ft. wide at the top, 40ft. wide at the bottom, and with an average depth of 125ft. Four steel drum gates, each 100ft. long and 16ft. high, will be fitted to the crest of each spillway. The spillway channels were excavated out of solid rock. The water in escaping from the reservoir over a spillway will drop into the side channel and turn at right angles before dropping into the upper portal of the tunnel that leads down to the connecting diversion tunnel. Extensive erosion tests were made to determine the wearing qualities of all concrete features of the spillways because of the velocities and the volume of water to be controlled. The water dropping from the spillway into either diversion tunnel will attain a speed of 120 m.p.h. The sides, the bottom, and the transition of each spillway are lined with concrete 24in. thick and the lining of the connecting inclined shaft is 36in. thick.

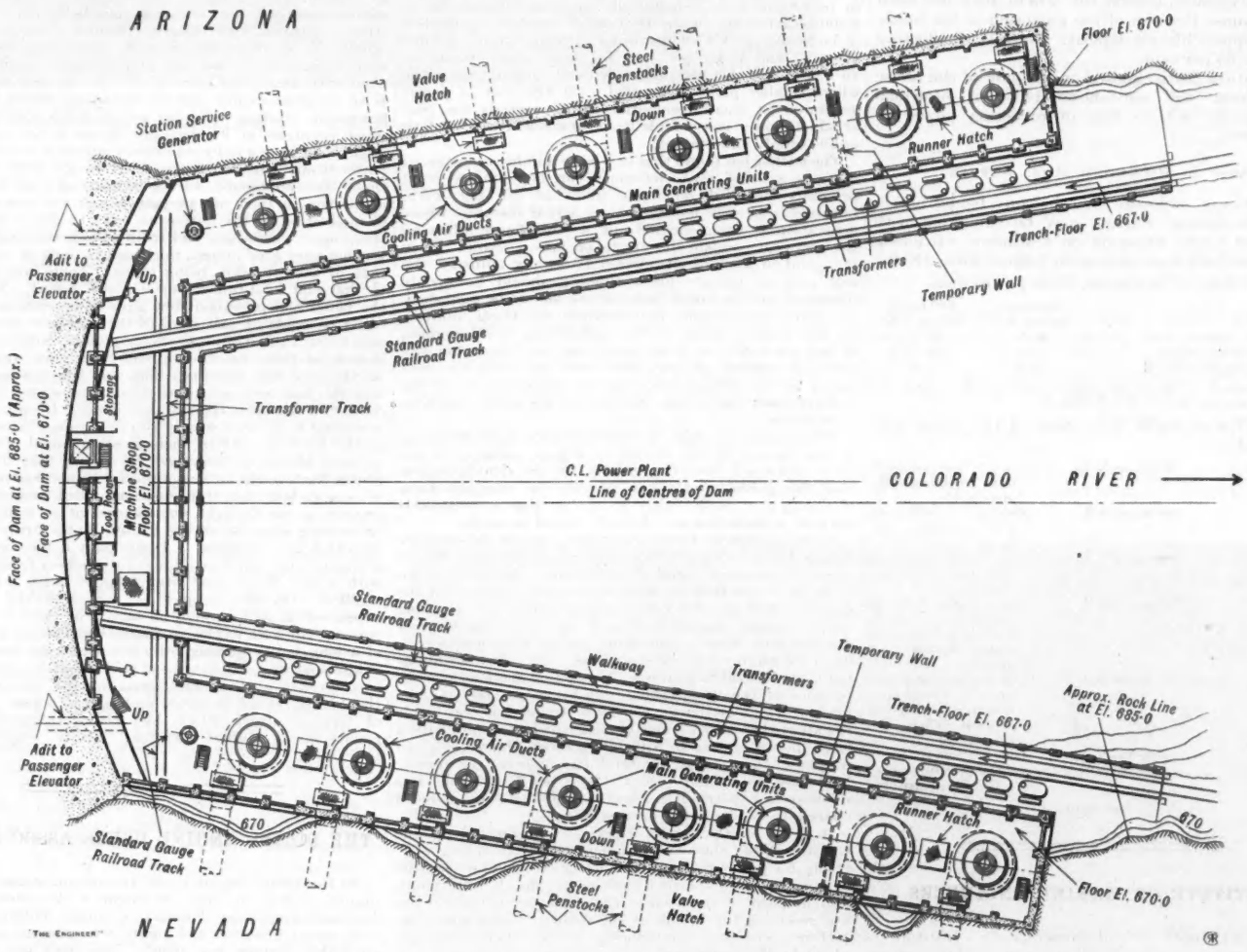
The Power-house and Penstocks.

Work on the reinforced concrete power-house is now well under way. The power-house—see below and page 223—is in the form of a U on the downstream side of the dam and paralleling the walls of the canyon. It will be ready for the emplacement of the generators in ample time to ensure the output of current as soon as impulse water is available in the reservoir. The preliminary installation will consist of two units, each of which will be rated at 85,000 kVA, and those units are to be supplemented a little later by a single 40,000-kVA unit. Ultimately, as the demand for energy increases, the power-house is to contain fifteen 85,000-kVA units and two 40,000-kVA units.

The Babcock and Wilcox Company, which has the contract to fabricate and to install the immense steel headers and penstocks for the distribution of water for power development and river flow regulation, is steadily turning out pipe sections 30ft., 25ft., 13ft., and 8½ft. in diameter. For some time now the sections have been undergoing installation in the several rock-driven tunnels within which they will be housed, and recently—September, 1934—that company has been putting in place the first of the 30ft. sections. The sections are moved to either flank of the canyon and there lowered to landing ledges at the portals of construction tunnels that lead directly in from the face of the canyon walls to the tunnels which run at right angles and which are the permanent housings for the pipe. The movement in from the canyon portal is by special cars that permit the pipe sections to be run off from either side of the underlying car and moved thence to its assigned position in the distributing system. The details of this particularly momentous and important feature of the entire undertaking are so numerous that we shall have to leave this subject for separate presentation some months hence. However, we can now touch briefly upon the trailer that is used to move even the largest of the pipe sections from the fabricating plant at nearby Bechtel, Nevada, to the rim of the canyon where the Government 150-ton cableway picks them up and transports them to either side and to any point in the underlying depths of the canyon.

The plant erected at Bechtel by the Babcock and Wilcox Company for the construction of the steel headers and penstocks is about 1½ miles away from the Boulder Dam, and the connecting roadway in some sections has a 6·5 per cent. gradient. To move the pipe sections from the plant to the cableway has necessitated the building of a trailer of unusual dimensions and especially equipped for the service. Although not self-propelling, it, nevertheless, carries two power plants, one which furnishes air to operate the wheel brakes and the other to actuate a pump of the oil pressure system which controls steering. This latter system is provided with interconnecting levers, so arranged as to swing all wheels in unison when oil pressure is applied. The wheels can be swung through an arc of 28 deg., which is sufficient to turn the trailer on a radius of 50ft. A small petrol engine drives the oil pump. A similar type of engine drives the air compressor for the brakes. The air for this purpose is stored in a reservoir, where it is automatically maintained at a prescribed pressure.

The main part of the trailer is a framework formed of structural steel shapes, and the two big longitudinal members are 152 lb. H-beams, 33in. in section. Pivoted to the framework at the centre are two drawbars, one projecting at each end of the carrier, fashioned from 10in. steel channels. The trailer is mounted on sixteen wheels, 28in. in diameter, and on each wheel are two 14in. wide solid rubber tires. Each tire is capable of carrying a load of 10,200 lb. The wide spread of the wheels assures ample stability when transporting one of the 24ft. long, 30ft. diameter pipe sections. The four wheels at each corner of the trailer are supported on two axles, and the axles are of the tilting, oscillating type, which compensates for common irregularities in the roadway without altering the load-carrying level to a marked extent. The wheels are mounted on double, tapered roller bearings. A compensating link interposed between the two main steering levers makes it possible to adjust the radius of travel of the inner wheels when advancing on curves so as to give all sixteen wheels a rolling action and to obviate drag that would be destructive to the tires. All steering is controlled from a single wheel mounted at one end of the carriage. The trailer has overall dimensions of 22ft. by 38ft. Heavy rubber-covered chocks receive the pipe sections and safeguard the coated surface of the sections while in transit. The loaded trailer is hauled by a caterpillar tractor, and when circumstances require it, a second tractor does pusher service. This trailer is but one of a number of special conveniences designed and built to meet the exceptional circumstances peculiar to the project at Black Canyon, and which will probably be scrapped when Boulder Dam is finished. The first of the 30ft. steel header sections were put in place in the form of elbows



BOULDER DAM—GENERAL ARRANGEMENT OF POWER HOUSE

at the bottoms of the intake tower shaft, and those installations were made during last July. Since then straight sections of the same diameter have been installed, and each of these latter sections, fitted with stiffening rings and support brackets, has weighed about 140 tons.

ILLUMINATION.

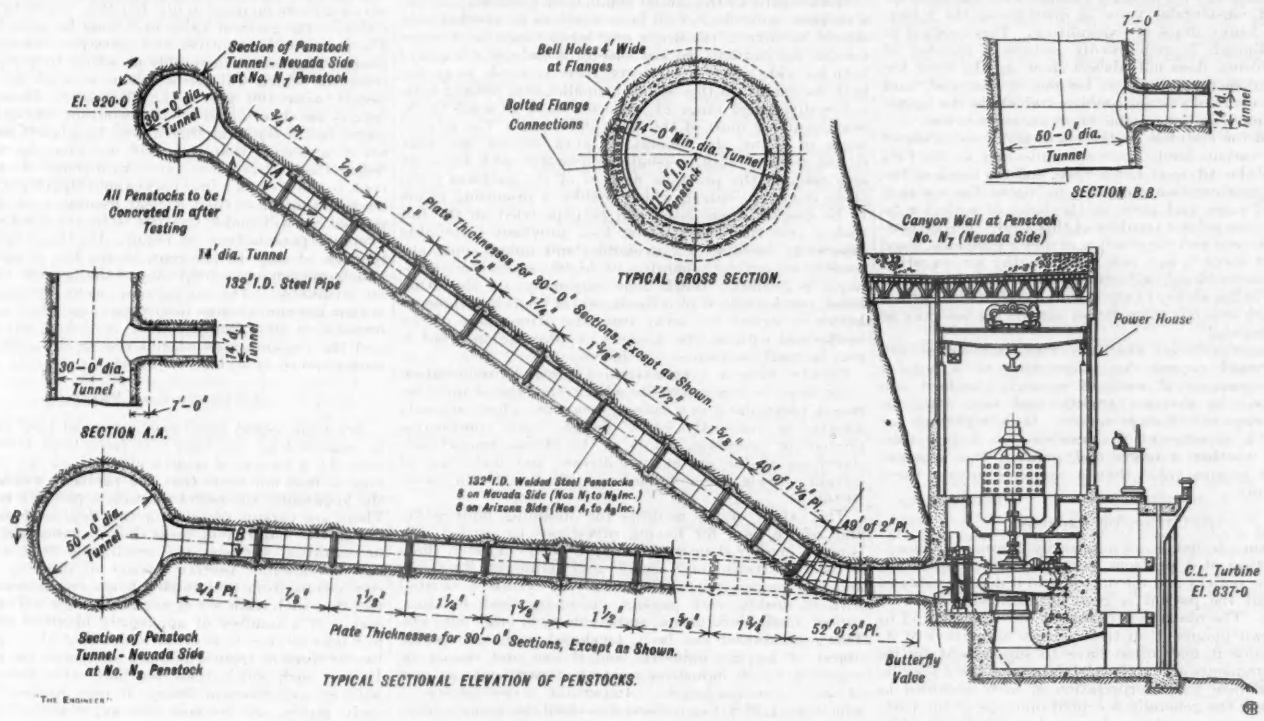
Construction activities at Boulder Dam do not cease with the set of sun, but are carried on night and day. This is true of the major operations of pouring concrete for that titanic barrier, and, of course, ample light for that purpose has to be furnished after nightfall. So ample has been the illumination that night workers have, so the records reveal, commonly placed more concrete per shift than crews doing like work in the daytime. No doubt more comfortable atmospheric conditions have aided in this. Two kinds of lights have been employed —that is, those that are moved with each pour to give greater localised illumination, and those that are of a semi-permanent character and intended to furnish sufficient general illumination. The latter, or fixed lights, are carried by brackets secured to the canyon walls, and are attached to the upper and the lower catwalks that span the canyon. These lights are supplied with bulbs of 1000 or 1500 watts, and are usually arranged in groups of from three to six at each position. They are also provided with large industrial reflectors. The portable local lights are flood-lights that carry dishpan reflectors. They are carried either on brackets or on tripods which can be placed or secured wherever they will best answer the needs of the workers. Strings of electric lights are provided in galleries, in the 8ft. central cooling slot, and at all other places where artificial illumination is called for either by reason of the nature of the work in hand, or the circumstances under which the work has to go forward.

TRANSPORTATION.

It has probably occurred to some of our readers to query how the men engaged on Boulder Dam, *per se*, get to and from their working stations quickly and with the least demand on their physical energies. To provide accommodations for the transportation of the men, and to adapt those facilities to the continually changing height of the dam, the contractor has in service three inclined skips, two on the upstream face and one on the downstream face of the structure. The railed platform on each skipway is large enough to carry fifteen men at a load, and each platform slides on greased skids, and a 15 h.p. motor handles the load. The operator of the hoist for a skip is stationed where he can see the entire skipway, and he controls the movement of the platform in response to signals made directly to him by the workers. A much larger skipway, which can carry fifty persons or a considerable load of materials, extends from the rim of the Nevada abutment down to El. 850. The men on the job commonly speak of the skipways as "monkey slides." One of these slides can be seen in the centre of the dam in the lower view on the right on page 226. These transportation conveniences have amply justified their installing. To obviate climbing up and down ladders when moving from one high block to another across an intervening lower block, the contractor has resorted to light-weight footbridges, built especially for the purpose. Two men, one at each end, can readily shift one of these bridges, and the practice is to put them in the desired positions while the forms for a block are being raised.

Inasmuch as some scaling of the canyon walls at the abutments is often found necessary just before the pouring of concrete, even though previously scaled, this rock must be disposed of as well as lumber scrap and other *debris* incidental to operations generally on top of the dam. All such materials are cleared away from the high blocks and placed on the upturned surface of the lowest adjacent blocks, which thus serve temporarily as catchalls. From these points, the *debris* is put in skips or buckets and removed from time to time by the cableway serving a given area. In this manner, cluttering is prevented, and there is, in consequence, a noticeable absence of litter so often present in much smaller kindred undertakings. This is merely one of numerous evidences of the careful planning and the orderly procedure which have made it possible to carry the project forward with a rhythm and speed that are truly remarkable.

This article has been made possible through the courtesy and the assistance of Dr. Elwood Mead, Commissioner of the Bureau of Reclamation, and Mr. R. F. Walter, Chief Engineer of that Bureau, and we are also indebted to Six Companies Incorporated, and to its chief engineer, Mr. A. H. Ayres.


Section of Penstock Tunnel - Nevada Side at No. N7 Penstock
El. 820·0
30'-0" dia. Tunnel
All Penstocks to be Concreted in after Testing
14' dia. Tunnel
132" I.D. Steel Pipe
Plate Thicknesses for 30'-0" Sections, Except as Shown.
Bell Holes 4' Wide at Flanges
Bolted Flange Connections
14'-0" Min. dia. Tunnel
11'-0" I.D. Penstock
TYPICAL CROSS SECTION.
7'-0"
50'-0" dia. Tunnel
14'-0" Tunnel
SECTION B.B.
Canyon Wall at Penstock No. N7 (Nevada Side)
Power House
30'-0" dia. Tunnel
14'-0" Tunnel
7'-0"
SECTION A.A.
132" I.D. Welded Steel Penstocks 8 on Nevada Side (Nos. N1 to N8 Inc.) 8 on Arizona Side (Nos. A1 to A8 Inc.)
40' of 1¾" Pl.
49' of 2" Pl.
50'-0" dia. Tunnel
C.L. Turbine El. 637·0
Section of Penstock Tunnel - Nevada Side at No. N8 Penstock
Plate Thicknesses for 30'-0" Sections, Except as Shown.
52' of 2" Pl.
Butterfly Valve
TYPICAL SECTIONAL ELEVATION OF PENSTOCKS.
THE ENGINEER

CROSS-SECTION OF POWER HOUSE AND PENSTOCKS

The Functions of a Research Department.*

By T. M. HERBERT (L.M.S. Railway Research Department).

LIKE most other railway companies, the L.M.S. Railway has possessed chemical and metallurgical laboratories for a number of years. Actually, the first railway laboratory was opened at Crewe as long ago as 1864, and in January, 1933, a separate research department was inaugurated, responsible directly to a vice-president, to include, under a single direction, the existing chemical, metallurgical, paint, and textile laboratories, together with a newly formed engineering research section. A further step has since been authorised in the form of the construction of a new laboratory to house the metallurgical, paint, textile, and engineering research staff.

One may ask at this stage why an independent research department should have been thought desirable, in view of the all-important need for close co-operation between the investigators and those engaged in day-to-day railway operation or maintenance. Whilst complete independence brings with it the danger of isolation, it was decided after very careful consideration that there were several strong arguments in favour of such an organisation. First, a large undertaking, such as a railway, is necessarily composed of a number of departments having separate functions and interests, and it is logical therefore that the research department should also occupy an independent position, as do the staff and accounting services, so as to stand in the same relationship to each potential customer. Secondly, a great economy in staff and equipment is possible in a single research organisation, as compared with separate research sections attached to each department. Further, the centralisation of scientific knowledge and experience avoids obvious tendencies to the overlapping of effort and enables results obtained in one direction to be quickly applied on similar problems wherever they may arise.

The independent status of the research department is in practice tempered wherever desirable by local arrangements, which ensure close direct contact with the different works and stores on questions relating essentially to routine work, and it should be mentioned at this stage that in most of the laboratories both routine work and research is carried on under the same roof, but in general by a separate staff. Such a combination of routine and research is not one which is universally advocated, but it is difficult to draw a hard-and-fast line between routine and research work, as the former is by no means always of a simple nature, and research often develops from results obtained in the course of routine testing. Whether a physical isolation of the research staff is desirable will depend largely on the type of industry with which one is concerned.

THE FUNCTIONS OF A RESEARCH DEPARTMENT.

The ultimate object of a research department is to assist in increasing the net revenue of the company in relation to its capital outlay. In the case of a railway company, it may achieve this result either directly, by pointing the way to savings in operating or maintenance costs, or indirectly by assisting in the development of better services to the public or in helping to avoid irregularities and failures in service. To play its part in attaining these objectives, the research department should carry out four main fuctions :—

(1) To discover and define problems in which scientific research can assist.

(2) To provide means, either internally or externally, for carrying out such scientific research.

(3) To act as scientific consultants to all departments.

(4) To keep the departments in touch with scientific developments relevant to their activities.

It will be noted that the work of a research department in an established industry is essentially of an advisory nature, whereas in many of the newer industries, *e.g.*, the electrical industries, it is largely in the research department that the ultimate products of the industry are born.

It may be wondered why the staff of a separate research section should be more fitted to perform the above functions than those who are in daily contact with the problems of the railway. It is true that the investigator often starts with the apparent disadvantage of not being closely familiar with all the details of the problem put up to him, but, on the other hand, he has certain definite advantages on his side. He has had a specialised training in the scientific analysis of observed facts ; he is an expert in the technique of measurement ; and he is familiar with outside sources of knowledge. Above all, he is free from administrative and routine duties, and has time to study each problem on its merits.

It is now proposed to describe the life history of a research problem, showing how each of the main functions of the department is brought into play at the various stages through which the investigation passes from its selection to its solution and application to practice.

LIFE HISTORY OF A RESEARCH PROBLEM.

Most industrial research problems can now be attacked without the fear of serious difficulties of method and technique. In almost every piece of industrial research, whether concerned with the development of some new material or process, or with the cause of some defect or trouble, there is a series of well-defined stages. First, there is the isolation or selection of the problem to be studied ; secondly, the exact definition of the selected problem and the collection of any outside data bearing on the subject ; thirdly, there is the laboratory stage proper, from which it is hoped that sooner or later certain suggestions will emerge ; fourthly, there is the demonstration stage of full-scale trial ; and, lastly, there is the application stage when the results are applied in general practice. The central or laboratory stage, whilst in one sense the most important, need not be considered in detail in this paper, since it is not peculiar to an industrial research

* The Institute of Fuel, February 13th, 1935.—Abbreviated.

organisation. The preliminary and final stages raise problems which do not arise in an outside research institution, and it is proposed to devote the remainder of the paper to discussing these problems and showing how they are being overcome in practice.

Selection of Problems.

The selection of subjects for research, particularly of major problems, is not a simple or automatic process. In any industry, factory, or department there will exist, it is true, a number of unsolved difficulties, but these do not always emerge readily as soon as a research department is formed. Many of them have been in existence for so long that they have come to be regarded as of the natural order of things, whereas they may well be capable of solution by the scientific methods now available.

Some of these partially obscured problems can be isolated with the help of the accountant, who can provide statistics showing the relative expenditure on different purchases or the ultimate unit costs of carrying out particular operations. Such an analysis of expenditure was one of the first steps taken by the L.M.S. Advisory Committee on Scientific Research, and a number of problems relating to the durability of paint and the wear-resisting properties of metals was isolated in this way. The fact that the Advisory Committee was partly composed of outside members, with no daily contact with the railway, was also of considerable value in questioning the reason for certain heavy items of expenditure. This method of selection, though it undoubtedly isolates a number of major problems, does not always show up the need for research on such subjects as failures of material, and necessarily overlooks minor problems which, in the aggregate, may have an appreciable effect on net revenue.

The need for research on the cause and prevention of failures of various kinds arose spontaneously at the first meetings of the Advisory Committee, and the heads of the different departments are coming to regard the research department more and more in the light of a doctor to whom they can submit troubles of this kind. The investigation of failures and the solution of minor problems, since they do not involve, as a rule, such lengthy investigation as the major problems, undoubtedly have helped to create confidence in the ability of the research staff to deal with a class of work which is often rather outside the province of the departments.

These minor problems, which may range from a relatively straightforward request for information to a subject requiring experimental work of research standard, are characterised by extreme variety, and very often an answer is required at short notice. It is important for the research department to ascertain, or, failing this, to judge, whether a quick and perhaps less accurate reply is of greater value than a complete answer three months hence.

Definition of Problems.

A problem selected is not necessarily a problem defined. The definition of a problem requires close co-operation between the patient and the doctor, and it does not always happen that the patient is good at diagnosing his own symptoms. The research department must be allowed to form its own judgment on the evidence submitted to it. This evidence it may often have to supplement by its own measurements and statistical data, and there may be a clash between the interpretation of facts obtained in this way and the generally accepted opinions of the past. This some may regard as a danger, but it is by the free judgment of the research staff that the fundamental problem, being perhaps hidden by tradition, is clarified. An American writer has put the point admirably in the following words:—

> "A research department should set an example by vigorously attacking the practice of depending upon unsupported opinions. Its suggestions and discussions should set forth conclusions, but it should be clear to all that such conclusions are the result of a careful consideration of facts, which should be enumerated and discussed, if the requirements of clarity make such discussions necessary. Opinions, like definitions, are so apt to remain unchanged long after the structures which originally supported them have changed, that close watch should be kept for the beginning of their obsolescence or unsoundness due to other causes. It is a common human tendency to feel that an opinion once expressed must be defended ever after, else a loss of prestige will result. It is much safer and wiser for a research department to assume the position that, as it interprets the facts as they are to-day, certain conclusions appear to be sound, but it is always possible for new conditions and new elements to appear at any moment which may render to-day's conclusions subject to modification."

At the same time, the research staff must guard against the danger of belittling existing methods irrespective of their merits. It should be ready and anxious to support long-established methods if actual facts show them to be fundamentally sound.

In order to effect a scientific analysis of the problem, the research department must set itself out to become a specialist in the technique of measurement. In many cases the facts required may be capable of exact measurement with suitable instruments, whilst in other problems it may be necessary to appraise somewhat ill-defined qualities. The latter, whilst not susceptible to direct instrumental measurement, can be judged with increasing accuracy by those whose training and experience in controlled observation enable them to assess the relative values of the different factors which go to make up quality.

The stage now arrives at which it should be possible to see what experimental work is required, but before putting this in train, it is most desirable to make sure that similar work has not been carried out previously in some outside institution. A survey of the literature of the subject is required, and this process, unaided, may be a lengthy one. It is at this juncture that close contact with organisations such as those described below can be of considerable value. They almost invariably maintain an efficient library and information service and are usually prepared to undertake the preparation of a short bibliography for inquirers. In the absence of facilities of this nature, the work will have to be done *ab initio* by the research staff in libraries such as the Patent Office Library in London. A research department may well find it desirable, however, to maintain a small information service of its own, even if this is started on quite a modest scale, and, as a matter of fact, the setting up of such an information section was one of the first steps taken in the case of the L.M.S. Company's research activities. Its object was partly to obtain on demand specific pieces of information from published literature and partly to keep a continuous watch for published scientific matter of interest to the main departments of the company. A monthly review of such published matter is now circulated to a large number of the technical officers as well as to the research staff, and makes available in abstract form a wide range of information which, for want of time and opportunity, was not previously available.

The lines upon which a simple service of this kind can be inexpensively run were described by the author in a contribution to the 1932 Conference of the Association of Special Libraries and Information Bureaux, and a recapitulation would be out of place in the present paper. Suffice it to say that the service has been generally appreciated, to judge by the response from the departments in the form of the requests received for the loan of original publications noted in the monthly review.

The Laboratory Stage.

With regard to the actual conduct of laboratory work, a decision must first of all be reached as to whether this should be done in the firm's own laboratories or at some outside institution. In the case of a railway company, with its wide range of interests, there is ample scope for both methods; in the case of a smaller firm dealing with a less diversified range of subjects, there is much to be said for doing most of the work internally. The advantages of doing the laboratory work oneself are that (i) the research staff is usually conversant with some, at any rate, of the practical aspects of the problem; (ii) there is closer control, which enables a promising result to be quickly appreciated and perhaps tried on the full scale; (iii) the cost is often less, provided reasonable laboratory facilities are available, and unless some unusually expensive apparatus or highly specialised technique is needed. Work done externally, on the other hand, particularly if of a fundamental kind, may prosper better if carried out away from the atmosphere of the works and without the dangers of interruption; but it may be costly and subject to delays.

Clearly, only a very extensive research organisation could hope to deal internally with every type of question raised, particularly in a railway company, whose interests directly or indirectly cover almost every conceivable product or operation. It is of the utmost importance, therefore, at the outset to cultivate and make use of certain outside research facilities which exist in Great Britain.

The extent of the facilities for obtaining information and advice, and for having investigations carried out, is much greater than is often appreciated. Firstly, there is the Department of Scientific and Industrial Research, and the various research stations and boards associated with it, dealing with physics, chemistry, fuel, building, timber, food, illumination, and a variety of other subjects. This organisation has been developed with the specific object of helping industry, and it can and should be regarded by all industrial research departments as part of their common assets. Important investigations in which the L.M.S. has utilised these facilities include those on the air resistance of trains, noise reduction in carriages, corrosion of boilers, and the various problems concerned with refrigerated transport.

Also associated with the Department, but supported primarily by individual industries, is a group of industrial research associations, and membership of certain of these bodies is the next step which a research department should consider. In point of fact, the L.M.S. Company is a member of six such associations. and the existence of a research department in the company enables full advantage to be taken of the research and advisory services offered. Those who question the value of subscribing to a research association should ask themselves whether they have provided the necessary channel through which the services of the association can be effectively brought into their own organisation.

In addition to these two main groups of research organisations, there is a great variety of other sources of help upon which a research department can draw. It is impossible to detail a complete list of such bodies, but within the last two years the L.M.S. Research Department has had occasion to consult the Imperial Institute, the Forestry Commission, the Animal Nutrition Research Station, the Research Department at Woolwich Arsenal, the Marine Biological Research Station at Plymouth—to mention only a few cases. Much work carried out in universities is of direct value to industry, and though there is, unfortunately, in this country, no central registry of such research work, experience enables one to know where the desired information is likely to be available.

It is worth pointing out at this stage the services rendered by the Association of Special Libraries and Information Bureaux, of which the L.M.S. Company is a member. This body describes itself as an association mainly for users of information, but its services often extend to indicating the existence and whereabouts of the lesser-known organisations carrying out research on the more out-of-the-way subjects.

Demonstration Stage.

Wherever conducted, most researches will sooner or later reach a stage when suggestions for practical trial can be made. A common mistake is to transfer laboratory results to the trial stage too soon, and it is very essential to be reasonably sure that a suggestion is really promising before requesting that a trial should be allowed. Naturally, only a proportion of such trials will be even moderately successful, but a flood of immature suggestions quickly discredits both the scientific ability and the practical common-sense of the research staff. On the other hand, once a trial has been agreed upon it should be conducted with sympathy and fairness, whilst, in making such trials, there must be some measure of co-operation between the practical side, responsible for development work, and the research side.

There is much difference of opinion as to whether the research department or the user department should carry out development work. In general, and particularly on a railway, where even small-scale trials may involve somewhat extensive preliminaries, there is much to be said for the user department carrying out such work, but in co-operation, of course, with the research staff. A definite advantage of this procedure is that the user is interested in the development at the earliest possible stage, and subsequent progress will be facilitated if the user begins to feel that he is playing a vital part from the outset. Against this, there is sometimes a danger of the development staff trying to do its own research, thus circumventing the whole purpose of the research department.

There is a very definite technique in the conduct of such practical trials. In the first place, care should be taken that a proper control or standard of comparison is set up. It is surprising that this precaution is sometimes overlooked, but to judge the behaviour of a new device or a new process merely by personal opinion unsupported by fact is clearly unsatisfactory. It is most important also for the research staff to appreciate what the practical side really needs. Such a statement may sound self-evident, but an example will serve to illustrate the point. Many research problems have, as their object, the prolonging of the life of a constituent part of plant or machinery. Laboratory research may show the way to, say, a definite increase in life, but this, in practice, may be either of the greatest value or it may be quite worthless. For instance, locomotives and carriages undergo periodic dismantling and re-assembly at which they are put in a condition which will enable them to work for a further period with 100 per cent. efficiency. These periodic repairs are determined by the condition of certain major parts, but at the same time a large number of minor parts are scrapped so that they will not give rise to trouble before the next repair is due. An increase of even 75 per cent. in the life of a minor part cannot therefore be utilised, since nothing less than a clear assurance of double the normal life will enable the part to function with certainty over two periods between repair. On the other hand, an increase of only 10 per cent. in the life of major parts, which determine the frequency of the periodic repair, may be invaluable. The points may seem obvious, but the author has come across numerous cases where a potential increase in life simply cannot be taken advantage of, and the research staff should realise this clearly at the outset and so avoid fruitless effort.

Application to Practice.

An unsuccessful small-scale practical trial can usually be regarded as conclusive, if fairly and honestly conducted; a successful small-scale trial, on the other hand, may or may not mean that the problem will be solved if the apparently successful solution is put into regular use. There are various reasons for this degree of uncertainty, but in the majority of cases there is some real difference in condition between the small-scale trial and every-day operation. Another danger of drawing too rapid conclusions from preliminary trials arises from the very fact that such trials are necessarily conducted on a limited scale. If a number of apparently identical machines is put into service, it is often found that there are always two or three of them which are inferior to the remainder. If one such sub-normal machine, therefore, is fitted with an experimental fitting, it may happen to require early repair, not because the experimental fitting has been unsatisfactory, but because, owing to some initial peculiarity, it would in any case have required repair earlier than the average of the group. The converse may be equally true; two or three out of each group of machines will show superior life, and if one of these is the experimental machine too favourable a view of the success of the experiment may be taken. The point to be made is that the final judgment should not be passed until a more extensive trial has discounted unavoidable variations between one machine and another. For this reason it is often wise to proceed in stages to full application of the results.

The association of the research staff with the conduct of practical trials will gradually result in these being carried out with greater precision and with correspondingly more convincing results. In this connection it is not out of place to remark on the value of negative results; to know definitely that a particular line of investigation is unprofitable often points the way to more hopeful fields, as well as avoiding expenditure of time and money.

ALLOYS.

In the article "Alloys" in the October issue of The Metallurgist, in which a paper by Hume-Rothery, Mabbott, and Evans was briefly reviewed, attention should have been drawn to the fact that the authors' liquidus factors in some systems are only claimed to apply in dilute solutions, and in such cases are by definition different from the reviewer's factors based on the first 80 deg. depression of the freezing point. The value 3 for aluminium-silver alloys in the column headed "Authors," should be read "slightly in excess of 3," since it was clearly stated in the paper that the depression of freezing point in this system was "slightly but systematically greater" than that to be expected from a factor of 3.

Addressing the Royal Statistical Society, Dr. K. G. Fenelon said that there were nearly 178,000 miles of road in Great Britain. Of this total, over 152,000 miles were in England and Wales and 25,500 in Scotland. The gross expenditure of local authorities in 1932–33 on highways and bridges, including loan charges, amounted to £64,000,000. Motor omnibuses and coaches carried more than 5,400,000,000 passengers in 1933. Despite the progress of the motor omnibuses, tramways still were of considerable importance. This, he said, was evident from the fact that they carried about 3,800,000,000 passengers a year. Trolly omnibuses in 1933–34 carried more than 254,000,000 passengers.

Rail and Road.

JUDGING from the answer given by Mr. Hore-Belisha to a question addressed to him on February 20th, the revised Highway Code proposes to change the old-established footpath rule of "Keep to the Right." The more acceptable rule will require pedestrians, where there is no footpath, to walk on the right of the carriageway.

IT is thirty years on March 1st since the Cairn Valley Light Railway of the Glasgow and South-Western Railway was opened. It leaves the main line at a point about 1 mile north of Dumfries, and is 17¼ miles long. The branch is exceptional in that it is a single track passenger line protected by Sykes lock-and-block, and not by any single line token system.

ABOUT 2 miles north of Ribblehead, on the Settle and Carlisle section of the L.M.S.R., the railway passes through Wold Fell, and, in what is known as Shale Cutting, an aqueduct carries a stream across the line. As a result of the heavy rainfall experienced during the preceding week-end, there was a considerable amount of flooding, and in the early afternoon of Wednesday, February 20th, a landslide occurred, and some 500 tons of material were washed on to the railway so that all traffic had to be diverted.

THE Ministry of Transport railway statistics for November show that, compared with the corresponding month of 1933, there was an increase of 5·6 per cent. in the number of passenger journeys made and of 4·8 per cent. in the receipts from passengers. The tonnage of freight rose by 1·7 per cent. and the receipts from freight traffic by 0·2 per cent. The freight train mileage was increased by 2·8 per cent.; the average train load remained almost stationary at 129¼ tons; but the net ton-miles per engine hour decreased from 467¾ to 458¼.

IN a lecture recently on the textile requirements of British railways, at the Textile Institute, Manchester, Mr. W. Pritchard, of the L.M.S.R. textile research department, spoke of the great change in the matter of coach trimmings. He said that instead of one standard cloth each for first and third-class compartments, there were now a number of pleasing designs and fabrics more suited to modern taste, and these added pleasure to railway travelling. In some of the newer coaches there was a different fabric for each compartment, with rugs and other accessories to match. Modern upholstering also enabled his department to recommend the use of cotton poplins and mercerised and fancy cotton materials for window blinds and curtains, where previously only silk and wool were used.

THE first of the annual reports and statements of accounts of the four grouped companies to appear is that of the Southern. The gross receipts from railway working during 1934 were £20,368,894, and the expenditure £16,070,478, as compared with £19,845,844 and £15,817,952 respectively in 1933. The increase in expenditure is accounted for by maintenance of way rising from £2,938,112 to £3,016,712, and of rolling stock from £2,316,792 to £2,330,286; locomotive running expenses increased from £3,954,015 to £4,018,686; and traffic expenses from £4,853,582 to £4,944,982. The total train miles for steam-worked passenger trains was 31,409,356, as compared with 31,032,597, of electrically worked passenger trains 25,899,658, as against 25,610,944; and of goods trains, 7,134,315, as compared with 6,886,177. The number of passengers carried, exclusive of season ticket holders, was 222,064,472, at an average fare per passenger of 10·89d., as against a total of 213,268,465, at an average fare of 11·08d. in 1933. The tonnage carried was 16,848,874, at an average of 5s. 9·35d. per ton, as compared with 16,232,906 tons, at an average of 5s. 9·2d. per ton.

THE Carlisle fatal collision of March 4th, 1890—forty-five years ago—although not a major event as regards the number of passengers (four) killed, was a memorable event, in that it was alleged that the vacuum brake froze. The train was the 8 p.m. from Euston, which had had an assisting engine that was detached at Shap Summit box. When the connection between the two engines was severed, the driver of the train engine closed the small ejector which was then used for overcoming leakages in the vacuum connections. The man, however, failed to reopen it, and so the vacuum leaked slowly away and was gradually destroyed, but the heavily falling gradient and a greasy rail prevented retardation, and so when, at the appointed place, the driver opened his brake valve, there was no vacuum to destroy; but instead of applying his steam brake and whistling for the guards' hand brakes, he took the pin out of the slide and converted the brake from automatic to "simple" vacuum. That released the wheels and disaster followed. The whole of the facts were subsequently related by Messrs. Leonard Archbutt and R. M. Deeley, of the Midland Railway, in two articles on "The Thermodynamics of the Vacuum Brake," in THE ENGINEER of June 27th and July 11th, 1890.

THE current (February) issue of the *London and North-Eastern Railway Magazine* has given us an opportunity to pass on some words of wisdom spoken by Mr. W. Whitelaw at the distribution of prizes in connection with the Mechanics' Institute, Stratford. He said that he had always thought that there were two things they could do for the younger people. First and foremost was to try and see that they had good homes and that they were properly housed, and then properly educated. To his mind, health came first. Without good health they could not be fully educated, and so he had always taken an interest in the health and homes of the people, and then in their education. After comparing the £150,000 granted by the State towards education in 1850 with the not far short of £50,000,000 paid to-day, and to what was now being done to abolish slums, Mr. Whitelaw said: "I am old enough to see slums which have been formed out of houses which were built to abolish slums. Unless the people will help in this great slum problem, it is impossible to get rid of them. It is possible to make slums out of good houses. So with education. Unless you do your utmost to take advantage of the opportunities, then these chances and the money Parliament is spending will be of comparatively little result. So we ask you younger people to play your part.

Miscellanea.

A TEMPERATURE recorded as one five-thousandth of a degree Fah. above zero has been reached in the laboratories of Professor Haas.

PETROL consumption in Germany during 1934 totalled 1,300,000 tons, of which 250,000 tons were home produced. Of 320,000 tons of benzol consumed, 280,000 tons were produced in the country.

ADDRESSING the road and building materials group of the Society of Chemical Industry, Dr. R. E. Stradling said that only 4 per cent. of street accidents can be traced to the material conditions of the road itself.

HIS MAJESTY THE KING has been graciously pleased to accord his Patronage to the Institute of Chemistry of Great Britain and Ireland. The Institute, which was founded in October, 1877, celebrates this year its Charter Jubilee, having been incorporated by Royal Charter granted by H.M. Queen Victoria in June, 1885.

ACCORDING to the statistics of the Ministry of Labour, South-East England is now the chief industrial area in England and Wales. The persons working in the counties of that region equal 36 per cent. of the entire industrial population of England and Wales, which exceeds the total of all the four northern regions put together. Greater London alone has an industrial population of 3,766,659.

THE Association of Special Libraries and Information Bureaux (ASLIB) is to hold its twelfth annual Conference at St. John's College, Cambridge, during the week-end beginning Friday, September 20th. A programme of lectures and local visits is being arranged, particulars of which may be obtained from the Secretary of the Association, 16, Russell-square, London, W.C.1. Sir Richard Gregory, Bart., has agreed to accept renomination as President of the Association for 1935–36.

AT a recent meeting of the Association of Mining Electrical Engineers, Mr. J. A. B. Horsley pointed out that any marked departure from the correct voltage for which an electric lamp was designed had a marked effect upon its life. He stated that a 5 per cent. over-voltage resulted in a 50 per cent. reduction of life, and that 2½ per cent. over-voltage reduced the life by 25 per cent. Lighting circuits, he said, should be devised so that the variation lays between normal and minus 2½ per cent.

A NEW method of dyeing wool was recently demonstrated at the Bradford Technical College. The customary method of dyeing wool at about the boiling point of water has some detrimental effect on the wool, but it has been found possible to dye thick wool at temperatures as low as 60 deg. Moreover, several dyes that have had poor penetrative power by the older method can be employed satisfactorily under the new technique. The fundamental principle of the new process is that a turbulence of the dye liquor during the dyeing is essential.

A NOTE in the *Chemical Trade Journal* says that the German firm, Ruhrchemie A.G., of Oberhausen-Holten, is building a large plant for the recovery of the liquefiable hydrocarbons contained in its coke oven gas before this latter is distributed to consumers through the long-distance pipe lines. It is estimated that Germany should be able to produce some 20,000 tons of this "Ruhr gas oil" per year. The material when liquefied is easily transported, and its fuel value is relatively higher than petrol, and it is said to be excellent for the starting of internal combustion engines.

SPEAKING at the Sir John Cass Institute, Mr. H. L. Pirie, of the Coal Utilisation Council, gave examples of economies that had been effected in certain industries. In the iron and steel industry 2·06 tons of coal were needed in 1913 to produce 1 ton of pig iron, but in 1932 only 1·82 tons were required. In the case of electricity generation, production increased from 1920 to 1929 by 143 per cent., but coal consumption at generating stations by only 34 per cent. The electricity output increased between 1933 and 1932 by 9·6 per cent., but only 4·95 per cent. more coal was used in generating it.

WE have received from the International Tin Research and Development Council the first of a series of Bulletins it is issuing dealing with the tin-plate, canning, and can-making industries. It is entitled "Tin-plate and Canning in Great Britain," and the researches include the investigation of the effects of the different soils on the crops used, the conservation of vitamins, the improvement of the quality of tin-plate, and many other subjects in which food producers, the manufacturers of tin-plate, cans, can-making machinery, and lacquers will be interested. The Department of Scientific and Industrial Research, the universities, and other research centres, and, latterly, the organisation that publishes the Bulletin, are collaborating. Short articles from the heads of the various research establishments describe the comprehensive character of the work, and show the prejudices against canned foods to be groundless.

ATTENTION has recently been directed to tarred cordage, a considerable amount of which is employed for marine purposes. As Manila hemp does not absorb tar satisfactorily, such cordage in the past has generally been made from European hemp. In order to investigate the effect of tarring on the durability of sisal cordage, the Admiralty recently carried out a series of experiments, the results of which are contained in the pamphlet just issued by the Imperial Institute, "Empire Fibres for Marine Cordage: Tests of Tarred and Untarred Cordage made from East African Sisal, Report of Exposure Tests Carried Out by the Admiralty, 1933–34." Ropes, 3in. in circumference, were prepared from East African sisal, one batch being made in the ordinary way from untreated fibre and another from yarn which had been passed through a bath of Archangel tar. Both kinds of rope were exposed to the action of sea water for periods of two, four, six, and nine months, their breaking strain being determined at the end of each period. It was found that after exposure to the action of sea water for nine months the untarred sisal rope had lost 76 per cent. of its initial strength, whereas the strength of the tarred sisal rope had fallen only 29 per cent.

Air and Water.

THE United States Secretary for the Navy, Mr. Swanson, has decided to oppose the further construction of navy airships.

AN air service between Hull and Plymouth with calls at Nottingham, Leicester, and Southampton, is to be inaugurated.

MORE than 2,500,000 miles were flown by the air liners of Imperial Airways during 1934. During 1933 some 2,300,000 miles were flown.

THE new L.M.S. Railway steamer "Slieve League," has been put into commission on the Holyhead and Dublin cargo and live stock service.

IT has been announced by the Postmaster-General that the weekly air service for correspondence is now available for French Equatorial Africa and the Belgian Congo, *viâ* France.

AS the Air Ministry has now sanctioned the new aerodrome at Ringway, Manchester, the Royal Dutch Airlines have decided that air liners on the Liverpool-Hull–Amsterdam route shall call at Manchester.

THE Board of Trade has appointed Mr. W. T. Williams, Deputy Engineer Surveyor-in-Chief, to be Engineer Surveyor-in-Chief in its Mercantile Marine Department, in succession to Mr. W. McAuslan, who is shortly retiring.

IT is reported that a £72,000 contract has been placed for the construction of an embankment on one side of the river Ouse channel, which may lead to a big plan for reclaiming foreshore and saltings which surround the Wash.

DURING January 179 vessels arrived and 178 vessels left Southampton docks; inward gross tonnage amounted to 1,086,338 tons and outward tonnage was 1,156,439 tons. Passengers arriving at the port numbered 6539 and departures 9464.

IT was reported at the monthly meeting of the Tyne Commissioners that the coal and coke shipments during January were 1,163,443 tons, against 1,281,481 tons in January, 1934. Vessels laid up at the end of January numbered 68, against 107 in January, 1934.

CLYDE shipbuilders have on order or under construction at present forty-four vessels with a gross tonnage of 255,195. This figure does not include small vessels, such as tugs, yachts, &c., or several vessels being fitted out for delivery. There are, in addition, some twenty-one naval vessels, aggregating 60,000 tons, on order.

A NEW fire-fighting float for the Thames, named the "Massey Shaw," has been launched at Cowes. The vessel is 78ft. long, 13ft. 6in. broad, with a draught of 3ft. 9in., and has a speed of 12 knots. She is driven by oil engines, and is so designed that it will be possible to pass under all of the Thames bridges at any state of the tide.

IN their preparations for floating the Cunard White Star liner "Queen Mary" to the sea, officials of the Clyde Navigation Trustees have encountered rock at a widening scheme at Rashielee, opposite Dalmuir. The rock has been found 18ft. to 20ft. below low water. The existing barge is unsuited for the new work, and the Trustees have authorised the purchase of a new diving bell barge, at a cost of £11,000.

AN interesting new type of clock is now being made for marine use. It shows both the standard and mean solar time without need for adjustment. A central dial revolves past stationary "hands," on which the names of places are marked, according to their times. In addition to giving the time in the ship's position, the clock thus provides a means of instantly reading the time in any other part of the world.

THE annual report of the Royal Dutch Air Lines illustrates the striking increase in passenger air transport on the Continent. The number of passengers carried during 1934 was 85,969, as against 41,707 in the previous year. Some 2,385,070 lb. of freight and 507,000 lb. of mail were also carried, an increase of 25 per cent. over the figures for 1933 for the mail, but freight traffic has been handicapped by quotas and tariff barriers.

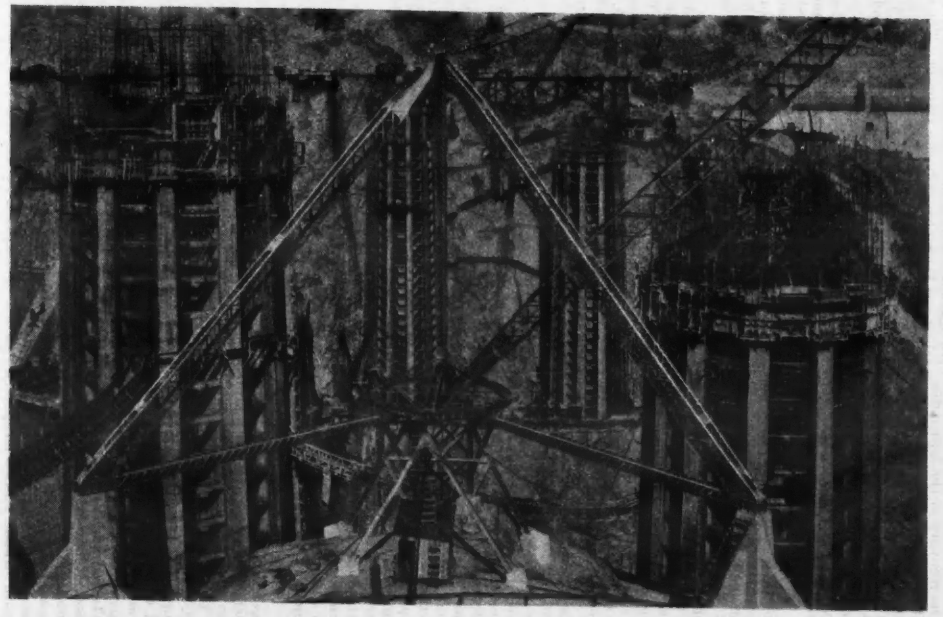
THE practicability of illuminating with electric signs the rear beacons of the measured nautical mile between Whitley Bay and Hartley is being considered by the North-East Coast Institution of Engineers and Shipbuilders, says *Shipbuilding and Shipping Record*. At each end of the mile course there are two beacons, one of which is close to the sea and the other a quarter of a mile inland. The four beacons are nearly 80ft. in height, but large vessels when well off the land cannot always, it is said, pick up promptly the rear beacons.

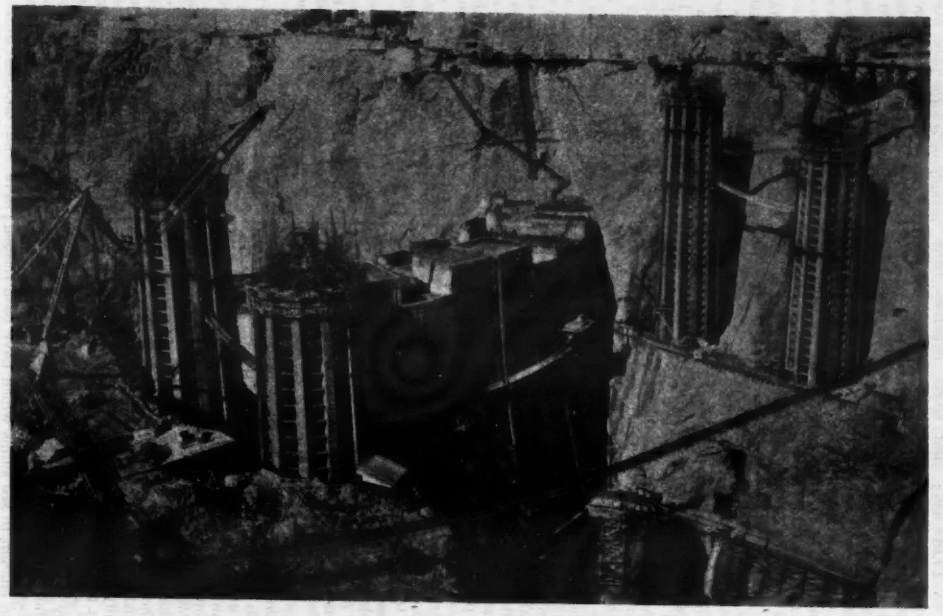
THE air correspondent of the *Daily Telegraph* has given some interesting particulars of plans, which are now being prepared by the air transport companies, to cover the British Isles with a comprehensive network of airways. The network will connect important inland points with coast towns and the ports of Great Britain with those of Ireland. The companies' plans are to link Aberdeen and London *viâ* Hull; Aberdeen and the Isle of Man *viâ* Glasgow; Belfast and the Isle of Man; Belfast and Manchester; Liverpool, Dublin, and Carlisle; Kirkwall (Orkney) and Lerwick (Shetland); Wick and Kirkwall. A number of the services will connect with Continental services.

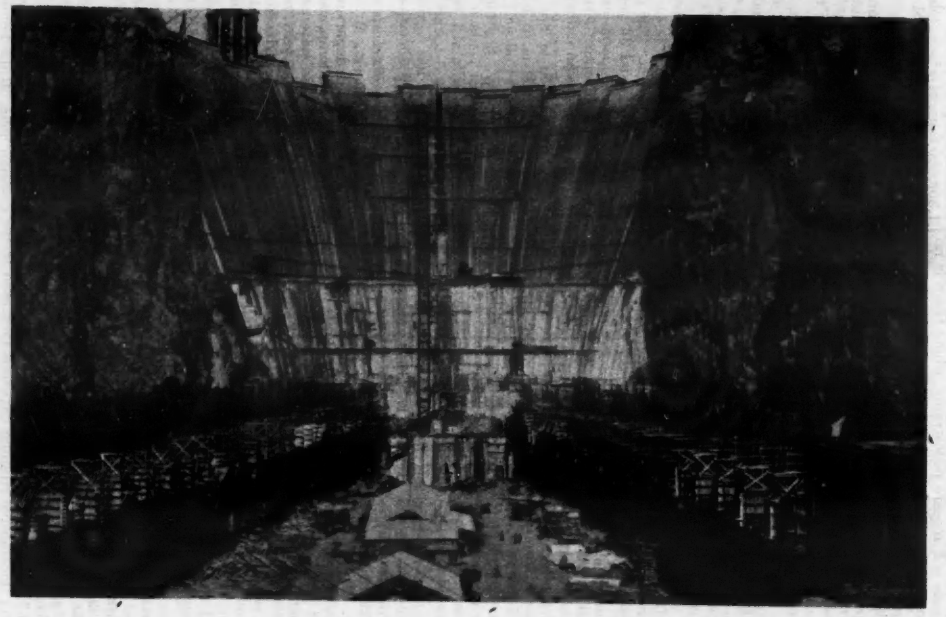
CONSTRUCTION is well advanced on the first oil-engined propelled passenger ship for pleasure service in the upper reaches of the Thames. The vessel, which has an overall length of 114ft. and a breadth over rubbers of 17·75ft., with a draught of 6ft. 6in., is designed to carry 350 passengers on a load draught of 3ft. She is owned by Captain A. Crouch, and is being built by the Rowhedge Ironworks Company, Ltd. Her propelling machinery will comprise a 125 b.h.p. Crossley oil engine, running at 450 r.p.m., driving a propeller in a semi-tunnel with a fully balanced rudder. The main fuel tanks will carry 2½ tons of oil. The new ship will be named the "Princess Royal," and will run from Westminster Pier to Kew and Richmond twice daily during the summer months.

PROGRESS OF THE BOULDER DAM

(For description see page 222.)







ABOVE:—CONSTRUCTING THE INTAKE TOWERS ON THE ARIZONA SIDE
BELOW:—UPSTREAM FACE AND THE FOUR INTAKE TOWERS

ABOVE:—GENERAL VIEW SHOWING ARIZONA SPILLWAY IN UPPER RIGHT-HAND CORNER
BELOW:—DOWNSTREAM FACE AND POWER-HOUSE FOUNDATION

The Engineer

MARCH 1, 1935.

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THE BOULDER DAM.

IN this week's issue we conclude a series of four articles on the Boulder (late Hoover) Dam on the Colorado River, in Nevada State. This dam is 300ft. higher than any other in existence, and runs the Great Pyramid very close as the largest solid mass of "masonry" in the world. In round figures, the Great Pyramid has a volume of 3,450,000 cubic yards; the Boulder Dam contains 3,400,000 cubic yards. The design of this immense dam is based on the results of prolonged and intensive research, laboratory experiments with model dams, and on data obtained from the full-sized 60ft. Stevenson Creek Dam, built for testing purposes in California. The methods of construction adopted are outstanding examples of engineering organisation, the efficiency of which is proved by the fact that the postulated date of completion has been anticipated by no less than two years. The systems of columnar construction, water cooling during the progress of the works, and internal grouting have enabled this huge monolith to be raised without any serious risk of the occurrence of cracks owing to the temperature changes which attend the uncontrolled setting of cement concrete. The maximum stress intensity when the reservoir is full will be over 33 tons per square foot. This is more than three times the intensity that has been considered safe in this country until recently.

The Boulder Dam is likely to remain the highest in the world for a long time to come, and a point has been reached from which a brief review of the previous history of masonry dam construction may be of interest. The earliest masonry dams were those built in Spain between the middle of the sixteenth and the end of the eighteenth centuries. They were amorphous masses of masonry, containing, in most cases, sufficient material to make two or three properly designed dams of a corresponding height. In the middle of the nineteenth century De Sazilly and Delocre published the results of their investigations into the distribution of stresses in masonry dams, and the principles then laid down by them, modified and extended by Rankine and other subsequent investigators, have remained the basis of the design of gravity dams until the present day. At about the same time the first dam curved in plan, and depending for its stability upon the transmission of the thrust produced by the pressure of the water to the sides of the valley by arch action, was built at Aix-en-Provence in the South of France. Thereafter for many years gravity and arched dams were looked on as two quite separate types. Such gravity dams, curved in plan, as were built were not considered as deriving any additional strength from arch action. In fact, some engineers believed that the arch introduced an uncertain and dangerous element into the design. On the other hand, arched dams were designed on the basis of a simple, but inadequate, formula, which disregarded any assistance that might be derived from gravity or cantilever action, but minimised the intensity of stresses produced by the horizontal arching, and ignored those resulting from temperature changes altogether. It is rather remarkable that, whereas it was considered essential that the maximum stress intensity in a gravity dam should be comparatively low, and eminent engineers and mathematicians spent much time and labour in devising formulæ for dam profiles which would ensure that the pressures were restricted to the limits prescribed, pressure intensities several times as great were allowed for in arched dams and sustained by them without any sign of injurious results. It is evident that the limitation of stress intensities to figures far below that which the masonry could safely bear has led to many dams in England being much more massive than is necessary. During recent years a number of "curved gravity dams" have been built in the United States. The Boulder Dam is the latest and largest of these, but there are other high dams whose profiles have been arrived at by the same method of design. In this both arch and cantilever action are taken into consideration, the apportionment of the water load between the respective elements being arrived at by a complicated and laborious process of theoretical adjustment of the loads borne by each, until the calculated deflections are equal at every point for both elements. This system, confirmed by the experiments previously referred to, has been accepted as more complete and satisfactory than any other, and has been successfully applied to the design of the largest dams so far built.

The Boulder Dam represents the greatest achievement of modern scientific dam engineering, but its shape and dimensions create to some extent an impression of an uncouth and unnecessarily large mass of material, and a feeling that the required result should be attainable in some more economical fashion. This ideal seems, nevertheless, somewhat remote at present, and there is little prospect of a dam of the height of the Boulder Dam being built of any other material than that made use of for a long time to come. Steel and reinforced concrete have been used for smaller dams, the former but rarely, the latter in many cases, the most remarkable example being the Coolidge Dam in Arizona, 250ft. high. But it would be a very bold engineer who would contemplate building a dam 700ft. high of either steel or reinforced concrete. Apart from other considerations, it would be necessary to take into consideration the doubts that would be felt as to the durability of these materials in so large a work. This suggests the question as to how long an engineering work should be expected to endure. The Boulder Dam will probably remain practically intact for a few thousand years, unless some cataclysm of Nature cuts short its life. Mankind will by that time have reached a stage of civilisation of which we can have no conception; or, possibly, our modern civilisation will itself have crashed into ruins and the human race will be once more struggling painfully to emerge from a state of primitive barbarism. In either case there is likely to be little use for any of the present-day works that may survive. Even within the next hundred years the condition of human existence will probably have changed to an extent undreamt of now. It seems, therefore, not unreasonable to suppose that the importance of permanence in engineering works is frequently exaggerated, and that such works should be usually designed for those whom they will benefit in the present and next two or three generations, leaving more remote posterity to solve its own problems in its own way.

The British Steel Market.

IT is expected that decisions which will have important consequences in the world's iron and steel markets will be made this month. The British Iron and Steel Federation and the Continental Steel Cartel will resume their discussions regarding the British market at Cannes on March 7th and 8th, and there seems at least a reasonable prospect that some agreement will be reached. It was expected that the Import Duties Advisory Committee would come to a decision before the end of February upon the application by the British manufacturers for higher duties on imported steel; but the industry is still waiting and it is understood now that the authorities are taking a healthy interest in the progress of its reorganisation. Since the duties upon iron and steel were imposed on the understanding that the British steel industry would rapidly be reorganised, it seems only reasonable for the Committee to ascertain how far this process has gone before making a recommendation to the Government. On the other hand, if the British and Continental steel makers have reached a stage in their discussions which promises agreement, the wisest course was to delay a decision. It cannot be denied that the British steel makers have solid ground for anxiety regarding the quantities of foreign steel which are entering the country, in spite of the duties plus a depreciated exchange which, together, it has been calculated, represent a tariff of over 80 per cent. Last year the imports of iron and steel and manufactures thereof reached a total of 1,366,600 tons, a very considerable increase over the figure of 970,800 tons in 1933. To make matters worse, the imports for January of this year were the highest for more than eighteen months. These sales of Continental steel in the British market have been almost entirely due to the fact that the foreign producer has been able to quote for delivery duty free at a price considerably less than that asked by the British maker of similar material.

We have never been amongst those who believed that a duty of 33⅓ per cent. would remove the difficulties of the British steel makers, and time has confirmed this view. At first the expansion of business in the home market owing to the diversion of orders from the Continental to the British works and the filling of stocks by merchants and consumers, created something like boom conditions; but the impetus given by the change in our fiscal system has lessened and the leaders of the industry are already facing problems not very dissimilar from those with which they struggled in Free Trade days. In addition to the heavy imports of foreign steel they have to consider the perplexing question of entering into a commercial alliance with the Continental Steel Cartel, and also to fit the industry into a bureaucratic scheme which is labelled "reorganisation." This scheme is designed to give the British works the control of their home market, whilst, of course, the import duties already in operation, the request for higher duties, and the proposal that Continental steel admitted into the country should be limited to an agreed quota, are directed to the same end. Great Britain has been for generations one of the most valuable of the Continental makers' export markets, and it is difficult for people in this country to realise the bitterness with which they regard our efforts to regain it. It will be seen, therefore, that the problem of the British market overshadows all others in importance, and, in fact, it is not too much to say that the future course of the international steel trade may depend upon the way in which it is solved. The discussions which have been proceeding between the British and Continental steel makers have made some progress, and it is understood that whilst the British have offered the Continent a quota of 600,000 tons per annum, the latter desires to secure 900,000 tons. A difference of 300,000 tons is not likely to form an insuperable barrier to an agreement. The matter is complicated, however, by efforts to determine beforehand the proportion of the different sorts of steel which shall be included in the quota, and in this the consuming trades, and particularly the re-rollers in this country, are deeply concerned. It may be that if the choice were left to them the British steel makers would prefer to secure the whole of the British home market for themselves and take their chance in the export markets rather than give the Continent an allotment; but there are obvious indications that the Government desires an agreement if possible. It may be presumed, therefore, that if the British and Continental makers come to an arrangement, little more will be heard of an increase in the duties.

In the midst of the discussions revolving round these complicated policies, the position of the home consumer seems to have received little attention. One reason is that the situation has undergone interesting changes during the past twelve months and reorganisation, so far as it

has been carried, has certainly lessened the opposition of the consuming trades by affiliating some of them to the Federation. For instance, a large proportion of the re-rolling interests have been brought into the reorganisation scheme, and no doubt hostility has been to some extent dispelled by other agreements between the different branches of the trade. It cannot be denied, however, that considerable uneasiness is still felt regarding the future course of events in the industry. Consumers of iron and steel expected that one result of the reorganisation would be to place the industry upon a competitive basis; but notwithstanding the progress made, the only movement in prices has been in an upward direction. It is obviously an important matter for users of steel to know if the limitation of imports and the further development of reorganisation will accelerate this tendency. So far it is understood that the negotiations with the Continent have not taken into account the export markets, but the reduction of Continental imports into Great Britain may make it necessary for other Continental countries, particularly Belgium and Luxemburg, to expand their exports in other directions. In fact, the drastic curtailment of sales of Continental steel in the British market, or, alternatively, its virtual closing by prohibitive duties, with which the Continental makers seem to be faced, may have incalculable repercussions in overseas markets and upon the future of the Continental as well as the British steel trade.

Worm Gears.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE Annual General Meeting of the Institution of Mechanical Engineers was held last Friday, February 23rd. The President, Mr. Charles Day, announced that Lieut.-Colonel Kitson Clark, who was retiring from the Council, had been elected an Hon. Life Member.

The presentation of prizes was then made, and subsequently the President formally moved the adoption of the Annual Report. Mr. Du-Plat-Taylor seconded, and the Report was adopted unanimously without discussion. An abstract of the Report follows:—

ANNUAL REPORT OF THE COUNCIL.

On December 31st, 1934, the number of members of all classes on the roll of the Institution amounted to 11,566, representing a net increase of 210 during the year. The Institution now has ten branches, nine in this country and one in South America. In January of last year the area of the Glasgow and West of Scotland branch was extended to cover the whole of Scotland and the name was altered to the Scottish Branch. The membership of the branches in this country varies from 203—South Wales Branch—to 1247—North-Western Branch. In connection with the scheme operated by the Institution in conjunction with the Board of Education covering the award of National Certificates and Diplomas in Mechanical Engineering, there were awarded among students of approved technical schools and colleges in England, Scotland and Northern Ireland 1140 ordinary and 525 higher certificates and 53 ordinary and 32 higher diplomas. The total number of candidates presenting themselves for these examinations was 3280.

During the year the Council appointed a committee to co-operate with the Institution of Electrical Engineers in the compilation of a set of standard "General Conditions for Engineering Contracts." An agreed set of conditions, it is hoped, will shortly be issued. The Inventions Advisory Committee, appointed in 1933 to encourage and assist members in respect of their mechanical engineering inventions, considered about twenty-five applications. In numerous cases the inventors were assisted by means of advice procured from experts in the fields covered by their inventions.

The Alloys of Iron Research Committee, a joint committee of learned societies headed by the Royal Society, concentrated upon the changes in the solid state of iron-rich and manganese-rich iron-manganese alloys. The Cutting Tools Research Committee continued its work during the year, Mr. E. G. Herbert making further investigations into the ageing of metals. A sub-committee of this body has been appointed under Professor Dempster Smith to study tungsten carbide tools. For the Pipe Flanges Research Committee active work was done at the National Physical Laboratory. Attention was directed towards determining the limiting conditions required to preserve tightness of a pipe flange joint at air temperatures, creep tests were carried out at high temperatures on bolts, studs, nuts, and washers and a study was made of full-sized pipes and joints under high temperatures and pressures. The Welding Research Committee pursued its work in a number of directions, including the ageing of welds, the hardness distribution in weld metal and the corrodibility of welds. The desirability of conducting large-scale tests of welded boiler drums is being considered.

The total revenue of the Institution for the year was £34,913 15s. 10d., and the total expenditure £33,758 9s. 1d.

The President next announced the result of the ballot for membership of the Council, as follows:—

President.—Colonel A. E. Davidson, D.S.O.

Vice-Presidents.—Mr. H. N. Gresley, Mr. David Roberts.

Members of Council.—Mr. Asa Binns, Engineer Vice-Admiral Sir Harold A. Brown, K.C.B., Professor E. G. Coker, Mr. H. L. Guy, Mr. Benjamin Irving, Dr. Pearce, Mr. Randall-Steward (Associate Member).

Speaking of the Report, he said that it showed the usual annual increase of membership, and that financially the Institution was in a very sound position, thanks to the activities of the Finance Committee. The Institution was fortunate in having a very active Council. Those who acted as Chairmen of committees were especially deserving of thanks. The outstanding feature of his year of office had been the establishment of the first specialised group. He was glad that he had been able to initiate and help the formation of the Internal Combustion Engine Group, and he hoped that it would form a centre in Great Britain for the discussion of problems connected with I.C. engines of all kinds. There were several other institutions dealing with special types of the engine, but none with all. There were the Institution of Automobile Engineers, the Institution of Aeronautical Engineers, and the Diesel Engine Users Association. But the I.C. engine group would deal with all types. All types of engine had many problems awaiting solution, and the major ones were common to all of them. He wished to draw the special attention of the members to the Spring Meeting of the group. Another specialised group had also been formed, but too late for inclusion in the report of the year. It was concerned with Education, and it was hoped that it would allow teachers, employers, and managers to meet and discuss the many problems the subject presented. Other specialised groups would be formed in time, and would much increase the usefulness of the Institution. He wished also to draw attention to the work of the branches, and especially to mention their Chairmen. The regular attendance of the Branch Chairmen at meetings of the Council necessitated a considerable expenditure of time and money, which was cheerfully undertaken. The Hon. Secretaries of the Branches also deserved mention. His year of office had been a very happy one. Everyone had been kind and General Mowat and his staff especially helpful. The time had now arrived for him to induct the new President, Colonel Davidson, into the chair. Colonel Davidson was Assistant Director of Works at the War Office. He was the first Army officer on the active list to become President. He was one of the senior Colonels in the Army, had earned the Queen's Medal with three clasps in South Africa, and had been mentioned no less than six times in despatches. In him they would have a President with an extensive engineering experience and a highly trained judgment. A great honour had been done him recently. He had been appointed Aide-de-Camp to H.M. the King. He (the President) hoped that Colonel Davidson's nomination as President had helped forward the grant of that honour. The close association between the Army and the Institution was of very great importance. Already in the Royal Army Ordnance Corps membership of the Institution was essential before a captaincy could be gained, and that condition would probably be extended. He would now ask Colonel Davidson to occupy the chair.

After taking the chair, Colonel Davidson thanked Mr. Day for the kind way he had inducted him into the chair. It was a great honour to be elected President of the premier institution of mechanical engineers in the world. It had never occurred to him thirty years ago that he might even become a Member of Council. He would do his utmost to do his duty as President. He thanked the Institution in the name of the Services for the way it extended greeting and friendship towards them, and he hoped that during his year of office it might be possible to let the members see something of the engineering difficulties with which the Services were faced.

Mr. R. W. Allen then proposed a vote of thanks to the retiring President, saying that his was an opportunity everyone would have liked to have. Mr. Day's year of office had been one of great success, on which he could look back with pride, pleasure, and satisfaction. Mr. Pendred, in a characteristically amusing speech, supported the vote, which was accorded with acclamation.

WORM GEARS.

The new President then invited Dr. Merritt to read his paper, entitled "Worm Gear Performance," of which we begin a reprint on another page, and the following discussion subsequently ensued.

From the chair Colonel Davidson said he was interested to find that the first paper which had come up for discussion while he was occupying the presidential chair was one dealing with worm gears, as shortly before the war, say, 1912, the War Department did not view with favour the use of worm gears in the final drive of their subsidy-type lorries. Great progress had been made since, and this type of gearing was now in general use. On the pre-war subsidy vehicles a double-reduction bevel drive was in general use, and although some manufacturers presented worm-driven axles for trial, the Department was not quite satisfied that they would stand up to the exacting conditions of a war, especially in view of the probability that the most suitable lubricating oil could not be provided at all times. At about that time, and subsequently, tests were published showing the very high efficiency of worms run under the most favourable conditions—that is to say, at high worm speeds and with lubricants of a type which probably could not be retained in the axle casings of vehicles under strenuous road conditions. Some four or five years ago tests had been initiated with heavily loaded worm gears in order to ascertain primarily what were the best lubricants to use in the axles. Those tests were intended to be run under the following conditions:—Worm speed, 130 r.p.m.; 7in. centre worm 7·33 : 1 ratio; load starting at 750 lb.-ft. torque, and working up to 2000 lb.-ft. The intention was to find the efficiency at the lower load and then increase the loads by steps with a view to ascertaining how long they could be carried without undue heating. The first thing that happened was that the apparatus was broken by the very high loads, but after strengthening, interesting results were obtained showing the following efficiencies:—At 750 lb.-ft., using castor base oil, 88 to 90 per cent.; using a certain mineral oil (which subsequently proved to be unsuitable), 85 per cent. As most of the published tests of worm efficiencies were in the order of 95 per cent., and considerably higher, those figures indicated that there was room for a further paper to be published giving particulars of the performance of heavily loaded worm gears at low speeds. Those were, of course, the most exacting conditions for the lubrication of worm gears, and it was thought that the damage done to them occurred under those conditions which might be rare in the life of a vehicle, but yet might occur often enough to cause a breakdown in lubrication. It might be that if a further paper was given on that particular aspect of worm gearing, it would be advisable to have the co-operation of a chemist with an engineer, as it was quite clear that certain types of oil would carry much heavier loads than others. As an example, a black mineral oil would not carry nearly as much load as a filtered mineral oil. According to tests, the castor base oil would carry 33 per cent. more load than a mineral oil, and certain other oils which had been tested, but were not entirely suitable for continuous use, would carry more even than the castor base oil.

Mr. Kerr Thomas congratulated the Institution on having a paper on this subject. The last on similar aspects of worm gear drive had been presented by Mr. Bruce thirty years ago. The analytical work contained in the paper was beyond controversy, but he had a certain number of questions to raise regarding the latter part. He understood that in the disc machine for testing the coefficient of friction the large disc was bronze. It would be an interesting experiment if the materials were reversed and the small disc made of bronze. He did not think the same results would be obtained. With reference to the graph relating coefficient of friction to rubbing speed, he presumed those results had been obtained with a castor-base oil. The author stated that the lowest coefficient of friction had been obtained with glycerine, but did not state the difference. Would the curve for glycerine be parallel to the other and lower? What was the lowest coefficient the author obtained? Had any experiments been made with a low-viscosity oil? Referring to the last graphs in the paper, were the efficiencies recorded there inclusive of churning losses? Or had they been obtained from a special apparatus which reduced churning? Some information on that point ought to be given in the paper.

Mr. V. Gartside was interested in tooth form. He said that Dr. Merritt drew attention to the tooth form adopted for the British Standard Specification. Owing to patents, &c., it was not allowable up to a few years ago for many firms to make this tooth form and a number of other forms had been used. Many tools were in existence for the production of those other tooth forms. He would like Dr. Merritt to supplement his paper with reference to these other tooth forms. In the production of the tooth form mentioned in the paper a flat-sided wheel was a simple and practical method of finishing. But in hobbing and in roughing out there were introduced certain difficulties. Were they more than balanced by the ease of finishing?

Mr. Robert Dumas said that he had been chairman of the committee responsible for the production of the B.S. Specification for worm gears. He would like to take the opportunity to say how much the engineering industry was indebted to gear manufacturers for the free way in which information had been put at the disposal of the committee. The standards produced were perhaps a departure from the normal, in that they partook of a text book nature. He felt especially indebted to Dr. Merritt. It was known that by grinding, worm after worm could be repeated with accuracy. Could hobs be made with equal facility? He remembered the days when the worm drive was only used as a convenient means of getting out of a nasty corner in a drive. It was a great credit to the manufacturers that the worm drive had been raised from that position to one giving a high efficiency. The durability had also been made very great. As curves in the paper showed, efficiencies were on the upgrade at the higher speeds. The information given as to the operation of the disc machine was very useful and a large number of experiments must have been made besides those on steel and bronze. Perhaps when the paper was printed the results might be added in tabular form. He was interested to see the improvement in performance as between centrifugally cast bronze and sand cast bronze. His experience with white metal bearings confirmed that result.

Dr. Aughtie said that there were some matters in the text of the paper that he thought must be misprints. The descriptive matter in connection with the diagrammatic representation of two-dimensional rolling and sliding was difficult to follow and seemed to imply that the amounts of rolling and sliding were equal. That was a matter that he would like Dr. Merritt to clear up. In connection with the disc machine, the occurrence of seizure before pitting was interesting. Pitting might be regarded as a form of fatigue failure. Did it occur in the same way as in spur gears? It was usually held that it occurred by the breakdown of the oil film at the point of pure rolling action.

Dealing with experimental measurements of efficiency he noted that the author had little regard for input and output measurement methods. The Daimler-Lanchester machine was essentially a machine of that type and was commonly regarded as the most accurate for the purpose. In his experience input and output methods had their limitations, first, because of the difficulty of establishing zeros of the machine to the dynamometer, and secondly, owing to inevitable small variations of mains voltage. It was, however, possible to obtain an accuracy within about $\pm \frac{1}{4}$ per cent.

Mr. Ernest Gregory spoke of the base line tangential pressure angle system, and said he had been using it with great success for the last fifteen years. He believed the standard specification which had been referred to would allow for the worm thread thickness to be less than was usually considered standard. That, surely, was a step in the right direction as engineers had always found wheel wear heavier than worm wear. He thought that the curves of efficiency loss towards the end of the paper needed qualification relative to application. If such figures were expected, even from good automobile mountings, members would be disappointed.

Mr. A. H. Fitt thought that not enough had been so far said with regard to lubrication. The method of spray was better in some respects than bath lubrication on account of the pumping action and consequent losses in the latter. The lower the viscosity of the oil the lower should be the friction losses. In connection with pitting, he said that it usually occurred at the maximum diameter of the wheel where it enveloped the worm. A worm drive had a certain practical disadvantage. With involute gears it was possible to vary the centre distance to a certain extent without ill result, but with worms it was necessary to have very accurate fitting. Even very small variations from the correct centre distance had meant disaster. Ball and roller bearings were the most suitable types of bearings for worm drives on account of the need for accuracy of setting. Continuing, he spoke of the question of noise. In ordinary gearing it was believed to arise from the repetition of contact of the teeth. But the worm had a sliding action, and where did the noise come from? Had it anything to do with the mounting of the worm and wheel? In connection with the disc machine, had the author found that wear and pitting were largely proportional to the speed?

Mr. Loughnan Pendred said that the production of worm gears was becoming a very specialised one. It would be possible to count on the fingers of one hand the number of firms engaged in it. It was not the business of the user to know how they were produced, but a natural inquisitiveness induced the mechanical engineer to ask. But was it a case where a British standard was really necessary? Who wanted it? He also pointed out that when efficiencies were in the range of 98 to 99 per cent., there was little to be gained by any change of form. He was quite certain all these points had been considered, but would Dr. Merritt give answers to them?

Professor J. J. Guest said that the paper formed a supplement to a British Standard Specification to be published shortly. To read it before the specification was published was rather putting the cart before the horse. What was the object? Was it that if the paper was received with acclamation it would strengthen the hands of the British Standards Committee?

Mr. A. L. Walker spoke on the production side. As long ago as 1910 efficiency tests had given values of 96 and 97 per cent. for worm drives. Tooth profile had not very much to do with it. Various firms used different profiles, but all of them had high efficiencies. It had been suggested that lorry drives formed the highest test for a worm drive. He thought a cotton mill drive should come first and next that of wire drawing. In connection with pitting, he was doubtful whether the author was right in thinking it to be a fatigue shear failure. His firm had been supplying gears for over thirty years. Recently, a worm and wheel, supplied in 1906, came back for attention. The wheel was badly pitted, but showed no signs of wear. Apparently, the pitting had assisted lubrication! He felt that if fatigue was present the wheel should have collapsed. As far as manufacture was concerned, it was quite easy to produce a very good worm. But the production of the wheel was quite a different matter.

Mr. Steel said that at the Bureau of Standards at Washington they had built a similar disc machine for testing lubricants. The results that they had obtained there for load at failure against the rate of increase of load suggested that the results the author had obtained should be interpreted cautiously.

Mr. Meacock said that some of his old friends seemed to have disappeared in the course of Dr. Merritt's paper. There was an allowable wheel torque which was expressed purely in terms of diameter. He would like to ask whether the actual pitch of the worm affected the allowable wheel torque? Would twice the number of starts, with half the actual pitch on the same load and with a shallower form of worm tooth, give the same results from the point of view of wear? In looking through the paper he could not find any particular method of ascertaining the addendum or dedendum or the height above and below the pitch line of contact. He would like to know how that was determined.

Mr. Stevens, speaking of the type of worm gear associated with the operation of lifts in which it is important that back lash shall be negligible, and the worm self-sustaining, said that the aim was always so to proportion the gear that under the maximum condition of loading the oil film was maintained. Out of sixty or seventy tests they had never found an oil which would carry more than two-thirds of the load carried by castor oil. The size and general proportions could, therefore, be smaller when castor oil was used for the same amount of wear.

Dr. Merritt replied shortly to the discussion, and promised to deal more fully in writing with the points that had been raised.

Literature.

The Life and Letters of Sebastian Ziani de Ferranti. By GERTRUDE ZIANI DE FERRANTI and RICHARD INCE. London: Williams and Norgate, Ltd. 1934. Price 12s. 6d.

THIS is a book for those who knew and loved Ferranti rather than for the earnest biographer. It is concerned principally with what may be roughly described as domestic matters, and the "letters" are a schoolboy's letters to his parents and a husband's letters to his wife. Mr. Ince is concerned principally with juvenilia and Mrs. Ferranti carries on the story to the end.

Mr. Punch has recently ridiculed in his friendly way the attention which biographers and autobiographers pay to childish things. Speaking by and large, it may, we think, be said that the importance of the childhood of great men is exaggerated; one might take the same period in the lives of ninety-nine non-famous men and find that it differed not a whit from that of the celebrated exception. But every now and then the boyhood of a genius is something out of the common, or, as in this case, merges so directly into the life and career of the man that the border line is invisible. If ever a man ought not to have been an engineer at all and yet was one from his cradle, Ferranti was that man. His whole family was artistic, and there was always a touch of the romantic in his temperament. But to the surprise and a little to the chagrin of his parents, he showed even as a very small boy that engines were his only joy. At school he was an inventor and a model maker, and before he was out of his teens he had produced the alternator which astonished and upset the electrical world. The letters from him which Mr. Ince quotes, and in a few cases reproduces in facsimile, are nearly all concerned directly with engines and machines or with pleas and defences against his father's coldness and objections to his predilection. They are admirable letters for a mere boy to have written; full, we are told, of spelling mistakes, but excellent in composition and far more mature than those of the normal boy. The fact is that Ferranti was born grown-up, and if he made mistakes—as in his magnetic engine with which he expected to put the scientific world out of countenance—it was only because he had not had the opportunity to learn, not because that he lacked the mature ability to acquire. But precocious as he was, there was rarely any trace whatever in him of the qualities which so often make advanced children detestable. The characteristic which gave him charm in his later life seems to have been with him from the beginning. We do not know on what principle Mr. Ince has selected the "letters," but from their nature we find it impossible to believe that the spirit of those that are not published differs materially from those that are. Mr. Ince has done his work well, and there is not a page of his narrative which may not be read with attention and interest.

Mrs. Ferranti's story is on a different plane. The writing of it has been an act of love, and we are sure that it will be valued by all who knew her husband. But it does little more than touch upon the scientific side of Ferranti's life, and we feel that some day some engineer should carry on the biography from the point where Mr. Ince has left it; thus tracing out the development and ripening to fruition of the characteristics of the boy.

We may add that the volume is illustrated by reproductions of letters, by portraits, and by sketches of inventions.

The Man Who Built the "Mauretania": The Life Story of Sir George B. Hunter, K.B.E., D.Sc. By WILFRID RUTHERFORD, Barrister-at-Law. London, 1934: Hillside Press. Price 7s. 6d.

SIR GEORGE BURTON HUNTER was born in Sunderland in December, 1845, just ninety years ago, and he still has a mind more active than many half his age. This book is a biography of him. Its chief claim to attention is that the author has endeavoured to reflect Sir George's thoughts and his reactions to the movements—technical, social, and political—which have occurred within his long life-time.

Young Hunter was apprenticed to William Pile, his first cousin, principal of a firm of shipbuilders in Sunderland. Before he came of age he was in charge of the drawing office as well as the "outside works." In 1869 he left Wearside for the Clyde, joining R. Napier and Sons as assistant manager. Two years later he returned to his cousin, and on his death in 1873 entered into partnership with Mr. S. P. Austin in an iron shipbuilding and repairing yard. There is, it seems, no evidence that the firm made a mark, and a few years later Hunter joined Mr. C. S. Swan at Wallsend-on-Tyne, and the firm of C. S. Swan and Hunter was established. The firm, as everyone knows, flourished. In 1895 it became a limited company with Wigham Richardson and Co., and the present firm, the builders of the "Mauretania," came into existence.

The biographer, besides giving an outline of Sir George's career and technical work, devotes chapters to his social and political activities and does not forget his efforts to bring about a change in the spelling of English. Sir George has always been a man with strong views and an energetic manner of presenting them. "Responsibility," says Mr. Rutherford, "came to him early in life, and for more than half a century responsibilities of a magnitude few men are called upon to face have been his lot, which he has faithfuly discharged. During this long period he has controlled many thousands of men and guided the destinies of innumerable concerns. He has rubbed shoulders with all kinds and conditions, occasionally coming into contact with the sharp tooth of 'outward circumstance,' and constantly learning something new about human psychology. His activities have been truly amazing. There is, perhaps, no other living industrialist who, apart from immediate interests, has spent such a crowded life."

Biographies written during the life-time of the subjects can never be more than partially satisfactory, but whilst we wait—and may it be many years before it appears—for a full life history of Sir George Hunter and his work, the present volume will be read with interest by his old friends and may, perhaps, show a few of a much younger generation the stuff that men were made of ninety years ago.

SHORT NOTICES.

Automatic Protection of A.C. Circuits. By G. W. Stubbings. London: Chapman and Hall. Price 15s.—An endeavour is made by the author of this book to deal with the automatic protection of A.C. circuits, not merely by describing modern protective gear, but by considering the theory of protective transformers, their interconnections, and protective relays. It is hoped that a preliminary study of the components of protective gear will not only assist the reader to understand the practical methods of automatic protection subsequently described, but will also place him in a position to assess the value of new protective methods which may be introduced in the future. Broadly, the book may be divided into five divisions, which cover protective transformers, the interconnection of these transformers to form protective circuits, relays, modern methods of protecting electrical machinery and transmission networks, and finally the testing of relays and protective circuits. The theory of symmetrical components is discussed under the heading of transformer interconnection. As protective gear now forms a highly important part of electricity supply systems, the book can scarcely fail to appeal to many power station and distribution engineers, especially in view of the ever-increasing attention which the subject demands.

Temperature and Latent Energy in Flame Gases.[1]

By BERNARD LEWIS[2] AND GUENTHER VON ELBE.[3]

IN a recent article Professor David[4] expressed the view that in mixtures of air with fuels, such as H_2, CO, CH_4, &c., the true flame temperatures are lower than the theoretical temperatures[5] calculated on the basis of adiabatic combustion, that this is due to the presence of "latent energy" in the flame gases in the form of long-lived abnormal molecules of some sort, and that the sodium line-reversal method of measuring flame temperatures yields results considerably in excess of the true flame temperatures.

Concerning the line-reversal method, David gave no consideration to the large amount of experimental evidence by which the validity of this method has been proved. This evidence consists of the agreement found by a number of independent investigators between the flame temperatures determined by the line-reversal method and the electrically heated wire method,[6] the electric conductivity method,[7] and the radiometric method.[8] In the electrically heated wire method the temperature of a wire is determined as a function of the current, first, when it is placed within a flame, and, secondly, in a vacuum. The point of intersection of the two curves marks the true flame temperature. The total energy dissipated is the same at this point whether the wire is in the flame or in a vacuum. Since the only sources of energy loss in a vacuum are radiation and conduction along the leads there can be no interchange of energy between the wire and the flame; that is, they are at the same temperature. In the electric conductivity method the equilibrium between sodium atoms, sodium ions, and electrons in a sodium-coloured flame is measured experimentally, and the temperature corresponding to this equilibrium is found from the Saha equation. The radiometric method depends on the determination of the emissivity of the flame from total radiation measurements.

It has been shown[9] that the above evidence in favour of the line-reversal method has not been invalidated by the arguments advanced by David.[10] In fact, the present authors believe the evidence is incontrovertible.

Similarly, David's evidence for "latent energy" in the flame gases must be questioned. The discussion centres around (1) luminosity experiments by David and co-workers; (2) measurements of the temperature of an unheated wire immersed in a flame, (*a*) deficiency of such temperatures compared to theoretical flame temperatures, (*b*) the effect of gas density on the measured wire temperature.

A study of experimental flame temperatures in open flames and maximum pressures developed in explosions in a spherical vessel and their comparison with the corresponding theoretical flame temperatures and explosion pressures, reveals that there can be no "latent energy" in the flame gases to influence to any extent the temperature or pressure developed. A mixture of hydrogen and air may be cited as an example. Since radiation from such explosions is negligibly small, [11] and the excitation-lag effect and water-vapour effect are absent,[12] the comparison is fortunately direct (Table I).

TABLE I.—*Comparison of Observed and Calculated Flame Temperature and Maximum Explosion Pressure.*

Per cent., H_2 in air.[13]	Flame temperature, deg. Cent.		Maximum explosion pressure, mm. Hg.	
	Observed.[14]	Calculated,[16]	Observed.[15]	Calculated.[16]
31·12	2045	2047		
36·72			5940	5949

With due consideration to the excitation-lag effect and water-vapour effect in certain types of mixtures, a similar agreement is found in other explosions of Pier, Bjerrum, Lewis and Von Elbe, Wohl and Magat[17], and also in explosions of David, Brown and El Din, David and Leah, and Thorp in their 18in. sphere.[18]

Only in the case of carbon monoxide air flames has a large discrepancy been ascertained between the measured and calculated flame temperatures[18] (the measured is 97 deg. below the calculated), the unaccounted energy amounting to approximately 5 per cent. in contrast to David's estimate of 20 per cent. Whether this difference can be accounted for quantitatively by radiation, which for CO flames is rather strong, there is at present no way of knowing. It is conceivable that strong emission takes place within the flame front where there is a high concentration of freshly formed CO_2 molecules. The recorded experiences of different investigators with CO flames points to the desirability of a more extensive study of such flames, particularly with regard to the distribution of the isotherms and radiation from the flame front itself.

In view of the above, we believe that the differences found by David and co-workers[19] between the experimental temperatures of their unheated wire and calculated flame temperatures are essentially due to uncorrected radiation loss from the wire and to the use of inaccurate heat capacity and thermal dissociation data. Otherwise their differences disappear to the extent shown in Table I, excepting, of course, where allowance has to be made for radiation loss from the flame. We feel that no satisfactory proof has been offered—

(*a*) that there is not a considerable difference between the temperature of the wire and the mass of gas[20];

(*b*) that the increase in wire temperature in denser mixtures is not due simply to the effect of density itself on the rate of heat transfer to the wire.

If the phenomena reported by David and co-workers are real, that is, are not due to the above implied or other causes, they should be reproducible also by the electrically heated wire method.

Finally, it may be mentioned that the reported[11] differences in pressures developed in explosions in vessels of different sizes which were offered as important evidence indicating the existence of "afterburning" or "latent energy," have been disproved experimentally by the present authors.[21]

Concerning the luminosity experiments. The beautiful snapshot photographs of Ellis and Wheeler,[22] taken at different stages of the explosion process in a spherical vessel, show conclusively that the duration of luminosity to which David refers[23] is due to emission from the central core of burned gas. On account of the temperature gradient which is established in explosions in a spherical vessel with central ignition, the temperature of this core at maximum pressure is 400 deg. to 600 deg. Cent. above the mean temperature inferred from the pressure.[24] Since "afterburning" was non-existent,[21, 12] it was obvious that the photographs of Ellis and Wheeler could be interpreted readily by this temperature condition.[21] David himself realises that the intensity and duration of the luminosity or after-glow depend only on the temperature of the inflamed gases,[23] but he believes it to be the temperature radiation of *abnormal* molecules, formed during the combustion, which remain stable for a long time. He supports his argument by the statement: "It is well known that gases like CO_2, H_2O, N_2, &c., in their normal condition when heated by external means to temperatures such as inflamed gases have in these experiments, remain dark." Perusal of the literature[25] on the subject shows that this is not so well known. In fact, the experiments have yet to be performed. To our knowledge, nobody has ever heated CO_2, H_2O, H_2, N_2, &c., and mixtures thereof externally to temperatures ranging from approximately 1800 deg. to 3000 deg. Cent. (the temperatures of the central core at various stages of the luminosity), and made luminosity observations. The temperatures at which such observations have been made are those at which gases formed in flames also remain dark.

To sum up, the conception of abnormal molecules of great stability in the flame gas carrying large amounts of latent energy receives no support from experiments purported to prove it, and is completely at variance with the known facts on flame temperatures and explosion pressures.

SIR,—In substance, the thesis of Drs. Lewis and Von Elbe is that the actual temperatures attained in flame gases are very approximately equal to those calculated on the basis of modern thermal data, and that therefore they do not contain the large amount of latent energy which I have postulated in my paper "Temperature and Latent Energy in Flame Gases." The issue is of considerable practical importance in that discrepancies between measured and calculated flame temperatures of the order of hundred of degrees Centigrade are in dispute.

Drs. Lewis and Von Elbe believe that the sodium line-reversal method of determining flame temperatures has been proved to give indisputably accurate results. They instance the case of a certain CO-air which when burning in an open flame yields a temperature measured by the sodium method which is only 97 deg. Cent. below the calculated, and that this corresponds to an "unaccounted energy of approximately 5 per cent. in contrast with David's 20 per cent." Now it is clear from other papers (of which they have been good enough to send me advance copies) that this mixture consists of 34·23 per cent. of CO, and is therefore an over-rich mixture. It is unfortunate that they should have selected such a mixture, for we have repeatedly emphasised that it is *particularly in the over-rich region* that the sodium temperatures are in general much too high, and the latent or unaccounted energy deduced from them much too low. Indeed, they might well have gone further into the over-rich region and discovered sodium temperatures which are equal to or even greater than the calculated.

Let us, therefore, take the case of a flame produced by the combustion of a "correct" CO-air mixture. Many independent observers have measured temperatures by the sodium method in CO flames, and their temperatures for the "correct" mixture, together with the latent energy deduced from them, are given in the table below:—

TABLE II.—*Temperature and Latent Energy in Flames; "Correct" Mixture of CO and Air.*

Method of temperature determination.	Temp. deg. Cent.	Latent energy per cent. heat of combustion	Observers.
Sodium line-reversal method (wet gaseous mixtures)	1935	16	Ellis and Morgan
Ditto	1890	18	Loomis and Perrot
Ditto	1760	25	Griffiths and Awbery
Platinum thermometry (relatively dry gaseous mixtures)	1875	22	David and Jordan

It will be seen from the table that the latent or unaccounted energy deduced from the sodium temperatures is large in amount and, indeed for this mixture, is not very different from that we deduce from our platinum thermometry experiments. It seems unreasonable therefore to deny the existence of latent energy in flame gases, even upon the basis of temperatures determined by the sodium method.

It seems clear also from the above that our platinum temperatures do not require a large correction for radiation as Lewis and Von Elbe suggest, for if they did the latent energy determined from them for this mixture would be actually much *less* than that deduced from the sodium temperatures.

Drs. Lewis and Von Elbe state that a large amount of work has been done which proves that temperatures determined by the sodium method are in agreement with those determined by other methods. The position is that such work has not been conducted over a wide range of mixture strengths, but only for isolated mixtures, *and in such cases where agreement has been found the temperatures are far short of the calculated and therefore show latent energy*, as in the case of sodium and platinum temperatures given in the above table.

The latent energy determined from the maximum pressures developed in exploded mixtures is of the same order as in flames in the case of such hydrocarbon fuel mixtures as we have up to the present experimented with—the latent energies being compared, of course, under conditions such that the explosion pressure and the pressure at which the flame burns are the same. In explosions of CO-air mixtures the latent energy is much less than in CO flames. Indeed, in the case of CO explosions made in a large explosion vessel, it is relatively small, as in the case of hydrogen explosions, also made in a large vessel, as stated by Lewis and Von Elbe. Here a most interesting problem presents itself for solution. I have already pointed out* that these results suggest, at any rate in the case of CO mixtures, that there is some essential difference between the nature of the combustion in flames and in explosions, and that the remarkable differences between the spectrograms for CO flames and CO explosions, taken by Professor Bone and his co-workers, support this view. It seems probable that the solution will ultimately be found in terms of the well-known facts relating to flame travel along a tube containing an inflammable gaseous mixture.

It is unnecessary to make any attempt to develop this view in this letter, but it may be said that support is lent to it by the fact that the latent energy increases in any exploded gaseous mixture as the size of the explosion vessel decreases. This we discovered by making pressure and heat loss measurements in spherical vessels of 18in. and 6in. diameter, and we have since confirmed by making similar experiments in a 3in. vessel. Lewis and Von Elbe deny this on the strength of some experiments which they have made.† But it should be pointed out that their vessels were not sufficiently different in size for a large effect to be produced, and the pressure record which they reproduce in connection with this work shows that they have not been entirely successful in their pressure indicating. An unfortunate oscillation seems to have made itself felt in the experimental system, and this should be eliminated before accuracy can be confidently assumed.

With reference to the statement that there is no evidence to support the view that normal gases remain dark at explosion temperatures of 1800 deg. to 3000 deg. Cent., it should be pointed out that the products of combustion after a gaseous explosion often remain luminous to the eye until they have cooled to a temperature of 1000 deg. Cent. or less. A large amount of work was done by Pringsheim and others in endeavours to obtain a luminous emission from normal gases at high temperatures, and Pringsheim came to the conclusion that these gases remained dark at the highest temperatures that could be obtained in the laboratory. Furthermore, flame photographs show that the glowing gases in the

* *Nature*, 134, October 27th, 1934, page 663.

† *J., Amer. Chem. Phys.*, Vol. II (1934), page 659.

interior of an explosion vessel *during the cooling period* are separated from the outer gases, which are dark, and presumably normalised by some means or other, by a very sharply defined boundary, but temperature measurements by platinum thermometry show conclusively that the temperature gradient across the boundary is wholly insufficient to account for the sudden extinction of luminosity which occurs there. Therefore, it is clear that the glowing gases on one side and the dark gases on the other side of this boundary are in a different physical state. This is very clearly shown in the flame photographs published by Ellis and Wheeler.

W. T. DAVID.

Engineering Department,
The University, Leeds,
February 14th.

[1] Contribution from the Pittsburgh Experiment Station, U.S. Bureau of Mines, Pittsburg, Pa. Published by Permission of the Director, U.S. Bureau of Mines. (Not subject to copyright.)

[2] Physical Chemist, U.S. Bureau of Mines, Pittsburg Experiment Station, Pittsburg, Pa.

[3] Coal Research Laboratory, Carnegie Institute of Technology, Pittsburg, Pa.

[4] THE ENGINEER, June 1st, 1934, page 558. See also *Engineering*, 138, 475, 1934, and David and Jordan, *Phil. Mag.*, 17, 172, 1934; 18, 228, 1934.

[5] For discussion of cases where the measured flame temperature lies above the theoretical temperature, see Lewis and Von Elbe, *Phil. Mag.*, in print, and *Engineering*, in print.

[6] Schmidt, *Deut. Phys. Ges.* 11, 87, 1909; Kohn, *Ann. Phys.*, 44, 749, 1914; National Phys. Lab., 1926 Report, page 63; Loomis and Perrott, *Ind. Eng. Chem.*, 20, 1004, 1928; Griffiths and Awbery, "Proc.," Roy. Soc., A 123, 401, 1929.

[7] Barnes, *Phys. Rev.*, 23, 178, 1924; Bennett, *Phil. Mag.*, 53, 127, 1927; also Noyes and Wilson, Astrophys. *J.*, 57, 20, 1923.

[8] Hersbey, *Ind. Eng. Chem.*, 24, 867, 1932.

[9] *Engineering*, February 15th, 1935.

[10] *Ibid.*, 138, 475, 1934.

[11] David, Brown, and El Din, *Phil. Mag.*, 14, 764, 1932.

[12] Lewis and Von Elbe, *J.*, Chem. Phys., in print.

[13] The mixtures contained known amounts of water vapour.

[14] Jones, Lewis, and Seaman, *J.*, Amer. Chem. Soc., 53, 2992, 1931.

[15] Pier's explosion No. 163; see Lewis and Von Elbe, reference 12, Table III.

[16] Calculations were made with accurate heat capacity and thermal dissociation data derived from band spectra. Tables of all such data available to date will soon appear in the *J.*, Amer. Chem. Soc. Method of calculation: For pressures, reference 12; for temperatures, Lewis and Von Elbe, *Phil. Mag.*, in print.

[17] See reference 12.

[18] See Lewis and Von Elbe, *Phil. Mag.*, in print.

[19] It is understood that one is dealing here only with experiments in which the experimental temperatures are below the calculated which forms part of David's evidence for "latent energy." Obviously, experiments in which the reverse was found are unsuitable as evidence for this purpose.

[20] The electrically heated wire method can be suitably employed for testing this.

[21] Lewis and Von Elbe, *J.*, Chem. Phys., 2, 659, 1934.

[22] *J.*, Chem. Soc., 310, 1927.

[23] David and Davies, *Phil. Mag.*, 9, 390, 1930.

[24] Lewis and Von Elbe, *J.*, Chem. Phys., 2, 665, 1934.

[25] See, for example, Franck and Jordan, "Anregung von Quantensprüngen durch Stösse," Berlin, 1926, pages 191–199.

A Capacity Booster.

A NEW booster for regulating the voltage of A.C. distribution systems has been introduced by the British Electric Transformer Company, of Bush House, Aldwych, W.C.2. It belongs to the class of apparatus that works without moving parts, and consists solely of a transformer with its secondary connected to a static condenser. The diagrams, Figs. 1 and 2, show the connections for a single and three-phase booster respectively. Considering the first diagram, for the sake of simplicity the incoming line is connected to one end of the transformer primary, and the outgoing line to one of several

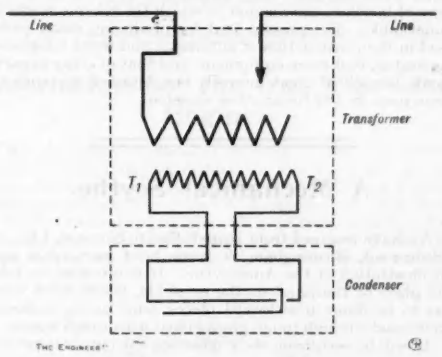


FIG. 1—*Single-Phase Booster Connections*

tappings (to be seen in Fig. 3), according to the boost required. Under normal operating conditions the combination of the transformer and condenser behaves in the same way as a condenser in series with the line, and it offers the advantage that it improves the power factor in addition to raising the voltage, the amount of power factor improvement expressed as a percentage being equal to the voltage boost expressed in the same way. Thus, if 10 per cent. boost is required when the power factor is 0·8, the power factor is raised to 0·88 at full load, and this figure cannot be varied without varying the boost accordingly.

While a series reactance lowers the overall power

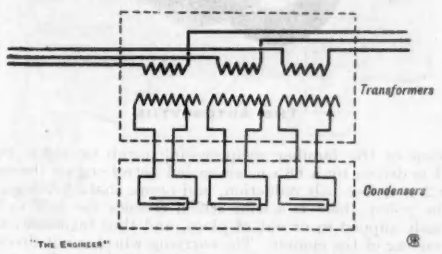


FIG. 2—*Three-Phase Booster Connections*

factor by virtue of the reactive kVA it introduces into the circuit, a series condenser introduces an equal reactive kVA of opposite sign so as to raise the overall power factor. Both these effects are shown in Fig. 4, which is a vector diagram for a 25 kVA, single-phase, 50-cycle capacity booster designed to give a 20-volt boost on a 230-volt system, the power factor of the load being 0·7. O A represents the input volts to the booster, and O B the line current. The current passing through the primary of the booster transformer includes a corresponding current, O C, in the secondary winding which has to pass through the condenser and builds up across this a voltage, O D, which is applied to the transformer secondary winding, and causes a proportional voltage, O E, in the primary winding, this being the voltage drop of the booster. Subtracting this voltage drop vectorially from the input voltage O A, the output voltage is found to be O F, which is greater than the input voltage, because of the phase of O E. The curves, Fig. 5, show how the full load boost obtained varies when the booster supplies loads of different power factors. In the case of a booster designed for a boost of 5 per cent. at 0·7 power factor, the 0·7 power factor ordinate meets the 5 per cent. boost position at the point A, and the curve on which this point lies gives the full-load boost obtained at other power factors, such as nearly 2½ per cent. with a 0·9 power factor load. In the case of a booster which gives 10 per cent. boost at 0·8 power factor, if it is required to know what boost it will give when transferred to a 0·6 power factor load, the 8 per cent. ordinate is followed until the point B is reached, and on tracing the curve to the 0·6 power factor point, the boost at full load is found to be 14½ per cent. In any particular case the boost at reduced load may be taken as proportional to the load.

If no special tappings are called for, the standard

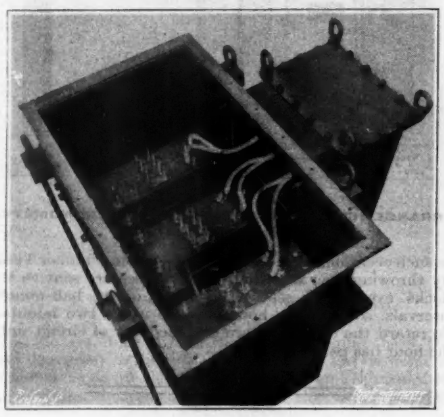


FIG. 3—*Booster with Transformer Cover Removed*

practice is to provide tappings which allow the boost to be reduced to 90, 80, and 70 per cent. of its normal value. The same tappings may also be used to adjust the booster for use on a load having a power factor differing from that for which it was originally designed. Suppose that a booster is designed for 10 per cent. boost at 0·8 power factor, and it is required to use it on a 0·7 power factor load and to obtain the same boost. From Fig. 6 it is seen that the boost at 0·7 power factor is 12½ per cent., and to reduce it to 10 per cent. calls for the use of the 80 per cent. tapping, which, when required, can be brought into service with an off-load tapping switch.

Reverting again to the vector diagram, if the capacity booster were removed, then the voltage O A would be supplied directly to the load, and the load current would be O B_1, lagging O A by an angle corresponding to 0·7 power factor. The application of the booster, however, moves the current vector O B_1 to O B, or nearer into phase with the supply volts O A, the actual power factor improvement being from 0·7 to 0·776, and this in itself will often appreciably reduce the voltage drop in the line, and so virtually gives a little extra boost quite apart from the advantageous effect on the generating plant.

The results obtained from the installation of a capacity booster can be seen from the examination of a typical case. Assuming the load power factor is 0·8 and that a 10 per cent. boost is required. Curve 1 in Fig. 6 gives the relationship between the percentage boost obtained and the load, the voltage variation being smooth and following approximately a straight line. The curve also indicates the improvement in power factor to be expected, since percentage improvement of this

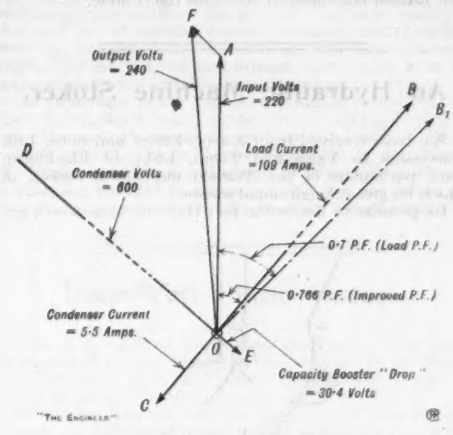


FIG. 4—*Booster Vector Diagram*

quantity at any load is equal to the percentage boost. A boost of 10 per cent. at full load is obtained in this case with a 10 per cent. improvement in power factor. Similarly, at half-load the curve indicates a 5·7 per cent. boost and 5·7 per cent. rise in power factor.

If the load power factor changes, or if it is desired to

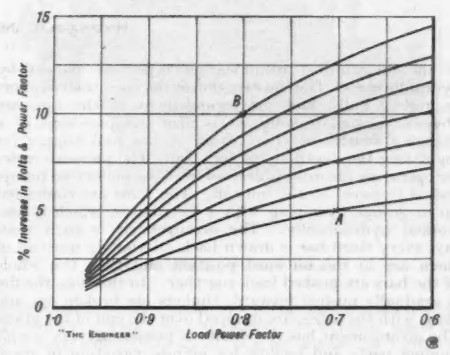


FIG. 5—*Variation of Full Load Boost with Loads of Different Power Factors*

install the booster elsewhere for use on another load of some different power factor, then reference to the other curves in Fig. 6 will show the boost obtainable. Curve 2 gives the relationship between boost and current when the load power factor is 0·7, and Curve 3 gives similar

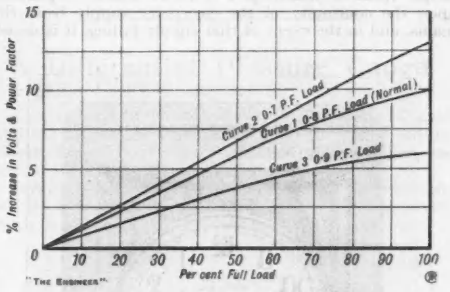


FIG. 6—*Variation of Boost with Different Loads and Power Factors*

information for a load power factor of 0·9. It will be perceived that the booster gives an increased boost as the power factor decreases, and since the line drop increases as the power factor falls, this is to be regarded as a desirable feature. At no-load the booster losses are nil, while

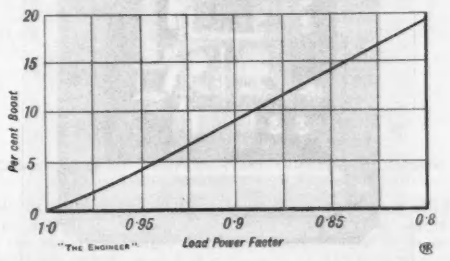


FIG. 7—*Maximum Boost at Various Power Factors*

the full-load losses are less than those of a transformer of corresponding capacity. For any given load power factor there is a maximum boost which cannot be exceeded. As the curve, Fig. 7, shows, a boost of 15 per cent. cannot be given at 0·9, but it is possible with a load power factor of 0·8.

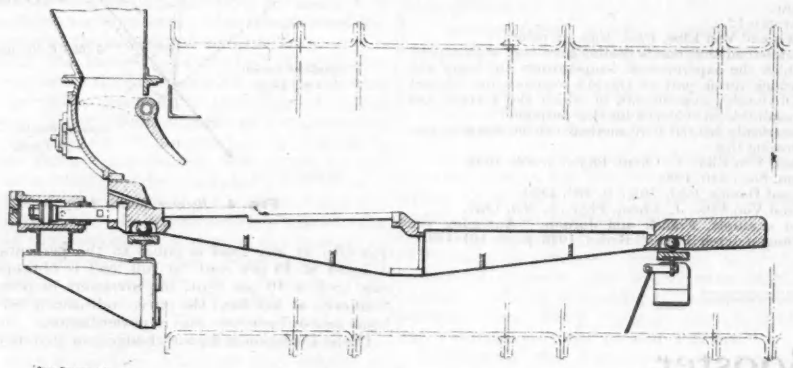
As the booster is devoid of moving parts and its opera-

tion is instantaneous, it can deal with voltage variations of a transient nature, such as are produced, for example, when a motor forming part of a mixed load is frequently started and stopped. Crane lift, mill motors, &c., are very liable to give rise to the flickering of lights, and the new booster is claimed to overcome the trouble.

An Hydraulic Machine Stoker.

WE have received from Joseph Foster and Sons, Ltd. (successors to Yates and Thom, Ltd.), of Blackburn, some particulars of the Nesfield mechanical stoker, of which we give a longitudinal section.

Its peculiarity lies in the fact that the bars, which are

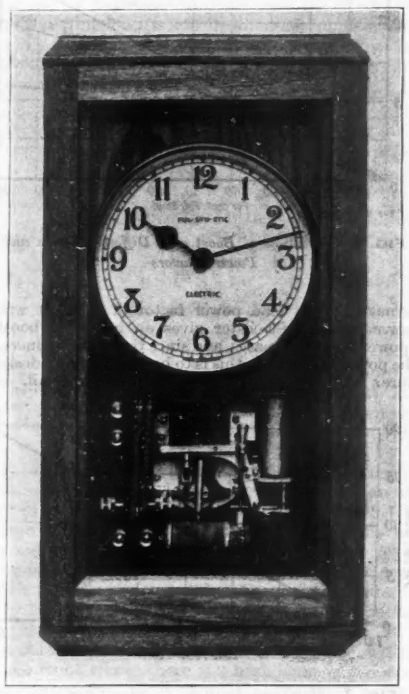


HYDRAULIC MACHINE STOKER

of the longitudinal reciprocating type, are moved by hydraulic rams. The construction of the bars, their support on rolling balls, and the arrangement of the ram are obvious in the drawing, as is also the provision of a swinging shutter at the bottom of the coal hopper for regulating the depth of the fuel bed. The pressure water for operating the rams is derived from the boiler feed pump, and is returned to the hotwell. The rams are connected up in groups by piping with a distributor, which is also worked hydraulically. The arrangement is such that, say, every third bar is drawn back alternately until all of them are in the outward position and then the whole of the bars are pushed back together. In this way the fire is gradually pushed forward, clinkers are broken up, and they, with the ashes, are dumped over the end of the grate. The arrangement has the merits of possessing very simple moving parts and facility for infinite variation in speed from that required for full load down to one-tenth of full load.

The Dac-Chronometer.

ALTHOUGH the synchronous electric clock is the most simple form of timekeeper, it is, of course, dependent upon the continuity of the electricity supply from the mains, and in the event of that supply failing, it is necessary to refer to some other form of timekeeper to set it right when the current is put on again. In the dac-chronometer system of Gent and Co., Ltd., Faraday Works, Leicester, this contingency has been guarded against.

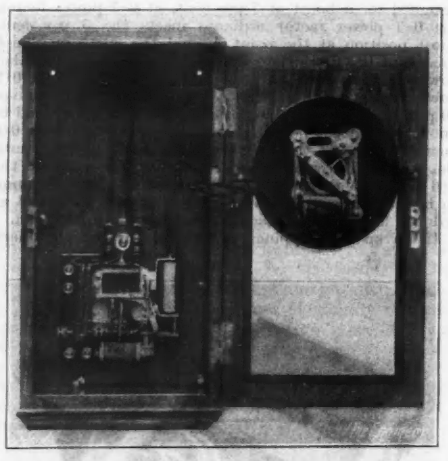


THE DAC-CHRONOMETER

The clock, of which we give illustrations, open and closed, is intended to be the master actuating a number of other distant dials on the Pul-syn-etic system of the makers, which is familiar to most of our readers. These dials have a very simple electro-magnetic movement, and move the hands forward every half minute by electric impulses received from the master clock. The dac-chronometer is driven by a synchronous motor from the mains, and as it runs at only 120 r.p.m., a comparatively small amount of gearing is needed between it and the arbors of the clock. Such gearing as is required is machine-cut, and the arbors are of hardened steel, with the exception of the rotor arbor which is chromium-plated. The rotor pivots run in self-lubricating holes.

In order to provide against a supply mains failure, the master clock is fitted with a standby motor of the direct-current type. It is series wound, but its speed is said to be absolutely constant, and it gets its supply of current from the accumulator which is used to operate the impulse dials. In the event of the alternating-current supply failing, the direct-current motor is immediately switched in and keeps the clock running until the resumption of the supply. It is then switched out again. The accumulator is kept charged from the A.C. mains by means of a step-down transformer and an all-metal rectifier.

One of the merits of this system of operating clocks is that it provides a simple means of altering their setting



ARRANGEMENT OF MECHANISM OF CHRONOMETER

on such occasions as the change to and from Summer Time. By throwing over a switch, the impulses are sent to the clocks every two seconds, instead of at half-minute intervals, so that one hour is made up in two minutes. To retard the dials they are switched out of circuit until the hour has passed.

New Telephone Factory.

SINCE we last had occasion to refer to the New Southgate works of Standard Telephones and Cables, Ltd., in 1923, when between the hours of 2 a.m. and 4 a.m. on January 15th a party assembled there to witness a remarkable wireless demonstration, organised to show that speech could be transmitted from America to this country, the establishment, then known as the works of the International Western Electric Company, has been considerably extended and improved. The 35-acre site on which the factory stands is adjacent to the L. and N.E. Railway, about 6 miles from King's Cross, and is close to the Great North and North Circular roads. At the centre there is accommodation for five 440ft. by 180ft. building blocks, with intersecting roads, 50ft. wide, but at present there are only three main buildings, with a total floor area of 365,000 square feet. The ultimate area of the factory will be 1,000,000 square feet without encroaching on the recreation fields at the extremities of the site.

At present the factory gives employment to 3300 workpeople, who carry out their duties under excellent conditions. In an extensive and well-equipped canteen meals are provided at low cost, while a hospital deals with accidents and illness. The main reinforced concrete factory buildings have three storeys, divided longitudinally into shops, 60ft. wide, stair wells being provided at each end and at the centre point in each long bay. The area of the ground floor is approximately 80,000 square feet, whilst that of each upper floor is approximately 60,000 square feet. One main building (No. 3) and the ground floor of a second building (No. 4) are completed. Both these buildings have been designed to permit ready extension by sections, according to need, and at the moment approximately 35,000 square feet is being added to form part of a second storey to the latter building. A group of single-storey buildings, including a woodworking shop, boiler house, junk-handling store, and inflammable store, is accommodated on a third strip of land, measuring 440ft. by 180ft., and on account of its central position it will eventually also accommodate an electric transformer sub-station. Part of the hospital building, which has been erected in pleasant surroundings, is utilised for interviewing people seeking work, but the hospital and employment departments are, of course, quite separate.

In carrying out the work of levelling the sloping site, preparatory to building, soil from the high ground was deposited on the low ground to enable the latter to be used as sports fields. Advantage was taken of the difference in levels to facilitate the handling of fuel, &c., the boiler house, which serves for raising steam for heating and other purposes, being at a level intermediate between that of the main buildings and the canteen, so that factory rubbish can be wheeled in at the floor level of the main buildings and tipped into a destructor on the boiler house floor below. Coal is carried by an underground conveyor from a pit on the railway siding to elevated hoppers in the boiler house, which feed the automatic stokers. Refuse from the woodshop is conveyed directly to the destructor, and is automatically fed into the furnace.

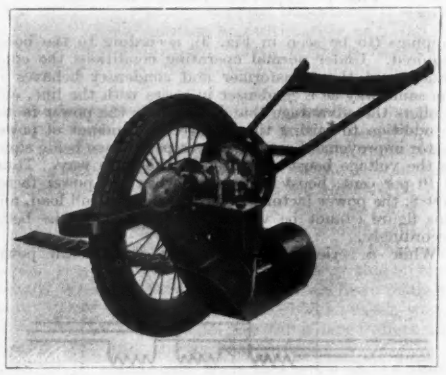
All current for lighting and power is obtained from the North Metropolitan Electric Supply Company, which has apparently been able to prove to the management that it can compete favourably with a private plant, notwithstanding that the works needs steam. At present, the only other building of outstanding importance is a wooden structure reserved for electrical tests which necessitate freedom from interference.

At a later date we hope to deal fully with the equipment and process associated with the factory, which is confined to the manufacture of telephone and wireless apparatus and equipment, cables and valves being made at Woolwich. A rapid tour of the machine assembly, winding, and other shops last week brought to light many ingenious devices for saving time and labour, but at the moment we are unable to do more than give a general outline of the arrangement of the works. We were particularly impressed by the method adopted in one of the departments for supplying the girls with materials. When an operator finds that she is running short of supplies, she places a box with indications of what she requires on a band conveyor which conveys the box to the stores, from which it is returned with the requisite goods on bands travelling in the opposite direction, and it is ultimately delivered with the aid of ingenious guiding devices to the point from which it was dispatched. Considering that the department contains many girls and that there are many rows of benches, the manner in which the scheme works is remarkable. The presses used for producing many parts used in the construction of automatic and other telephone apparatus, tool-room equipment, and that of other departments, are all of great interest, but detailed reference to them must be left for another occasion.

A Mechanical Scythe.

WE have received from British Estate Services, Ltd., of Tilton-road, Birmingham, 9, some brief particulars and an illustration of the Autoscythe. It is intended to take the place of the hand scythe or sickle, where hard work has to be done in awkward places, such as on embankments and through rough grass mixed with tough weeds.

As will be seen from the engraving, the cutter takes the



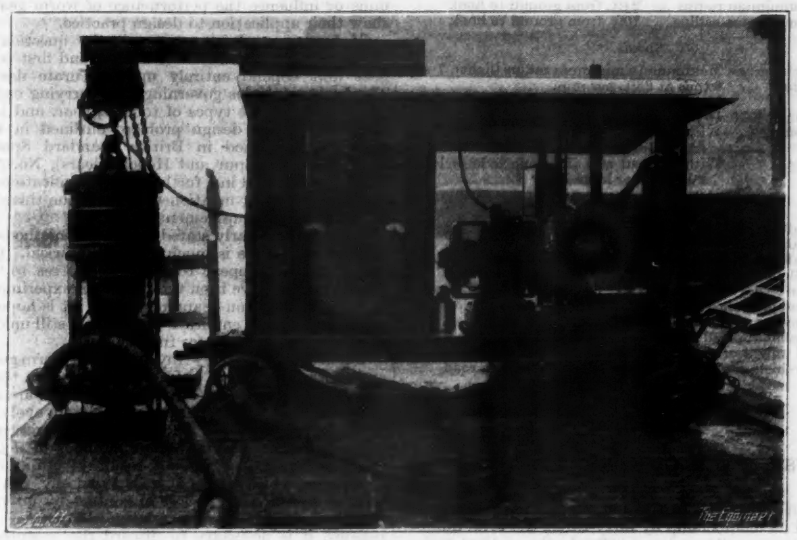
THE AUTOSCYTHE

form of the familiar reciprocating comb or sickle bar. It is driven by a 68 c.c. air-cooled petrol engine through a 2 to 1 Vee belt reduction, and crank shaft. Alongside the pulley there is a cone which enables the belt to be easily slipped in or out of place, and thus facilitates the starting of the engine. The carrying wheel is not driven, so that the scythe can be pushed up to its work just so fast as it can make a good cut, and there is no tearing action on the grass. With a 3ft. cutter bar the machine will cut about 2 acres of normal grassland a day.

A Portable Electric Pumping Set.

THE portable electric pumping equipment shown in the accompanying illustration is used by the Wakefield Corporation for cleaning sewers where they pass under the river Calder and the canal. The generating set consists

of a Petter 16 h.p., 1500 r.p.m. oil engine directly coupled to a Bruce Peebles 10 kW, 220/230-volt, protected-type dynamo, which, like the pump, is controlled from an Igranic switchboard, specially constructed for the purpose. A winch with 35ft. of three-core armoured cable is fitted with a pawl and ratchet and three slip rings for making the connections between the motor and switchboard,



PORTABLE ELECTRIC PUMPING EQUIPMENT

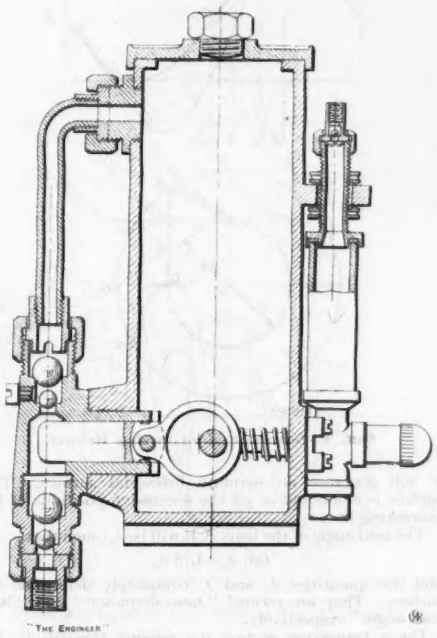
and by paying out the cable enables the pump to be operated at the desired level. The winch was made by Green and Smith, Ltd., Leeds.

A Herbert Morris pulley block supports the pump unit, which consists of a Peebles 10 h.p., 220-volt, 900 r.p.m., vertical-spindle, drip-proof motor driving a 3in. Blackstone unchokable pump with a maximum output of about 330 gallons per minute against a total head of 30ft. In addition to supplying current for driving the pump motor, the 10-kW dynamo also serves for lighting when the equipment is operated at night. The equipment is used for cleaning out accumulations of solids from the bottom of the syphons formed by vertical chambers sunk at both sides of the river and canal to permit of the main sewers passing under them.

Lubricators for the Iraq Pipe Line Engines.

WE give below a sectional drawing of one of the lubricators for the pumping engines on the Iraq pipe line, to which reference was made in our issue of February 15th. They were supplied by J. and W. Kirkham, Ltd., of Bolton.

These lubricators, which have sixteen branches for forced lubrication, differ from the standard T and K type, in that they are equipped with five special pumps,



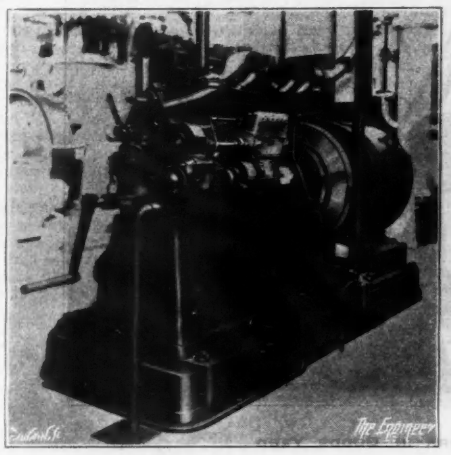
LUBRICATOR FOR IRAQ PUMPING ENGINE

shown on the left in the drawing, each capable of delivering 1¼ pints of oil per minute. These pumps have plungers 1⅛in. in diameter by ⅝in. stroke, and are, as will be seen, driven off the excentric shaft of the lubricator. They obtain their oil supply from the main tank beneath the lubricator, and the centre pump feeds the lubricator container, which is provided with an overflow back to the tank so as to keep a constant level in, and a circulation through, the container. The outlets from each pair of outer pumps are connected together and are taken to the pinion shaft bearings of the main sets. The overflow from these bearings is returned to the supply tank, being filtered *en route*. The lubricators are driven by means of chains protected by cast aluminium cases. The chain is lubricated by any oil, which may leak along the excentric shaft to the end and accumulate in the case. Any overflow goes to the pinion shaft bearing.

In view of the fact that these lubricators were made to a special specification, which entailed their passing a smoke test, the normal regulator for the stroke of the pump was modified, and it is, in this case, protected by a dust shield, while a special hand-flushing appliance is provided. The oil container is of cast iron, weighs a hundredweight, and has a capacity of 5 gallons.

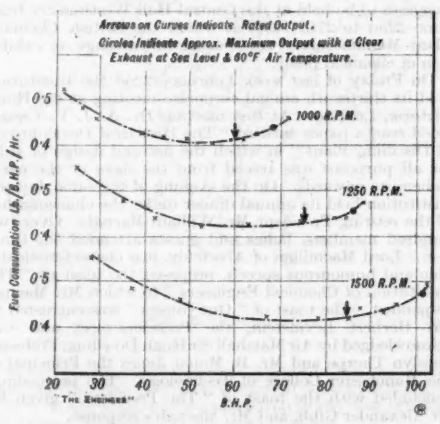
85 B.H.P. Generator Set.

WE illustrate herewith a new type of oil engine driven generating set, which has been evolved by the Associated Equipment Company, Ltd., of Southall, Middlesex,



85 B.H.P. GENERATING SET

from the standard A.E.C.-Ricardo oil engine, used for road transport purposes. The new set has undergone extended tests at the maker's works, and typical fuel consumption curves are given in the accompanying



FUEL CONSUMPTION CURVES

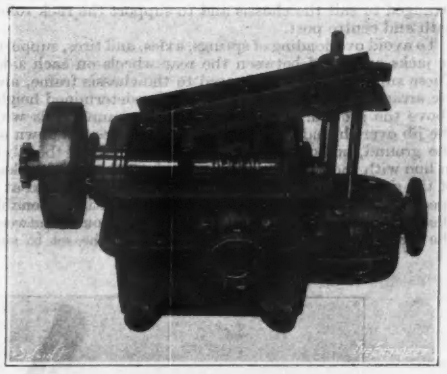
drawing for speeds of 1000, 1250, and 1500 r.p.m. The engine, which has a bore of 115 mm., or a little over 4½in., and a stroke of 142 mm., or nearly 5½in., has a rated output of 85 b.h.p. at 1500 r.p.m. It is shown coupled direct to an English Electric 60-kW D.C. generator. The overall length of the set is 8ft. 3in., and its width 2ft. 8½in., making a very compact unit. The weight of the complete set is about 2½ tons, but this can be reduced if an aluminium alloy bed plate is used. The engine follows the standard design of the road transport unit, and is complete with lighting dynamo, and engine-driven fuel, lubricating oil, and circulating pumps. The governor has been specially designed for alternating-current working, and parallel running, and when fitted with an automatic electric starter the set will, we understand, start up in 20 sec., while it can be run on full load within 47 sec.

An advantage of the engine, the maker points out, is that standardised spare parts can be obtained, either from the maker's works or road service stations. For marine work the design has been approved by the Board of Trade and Lloyd's Register of Shipping. Where engines are installed in groups, the builders are prepared to make an agreement for their complete maintenance.

Deep-Well Pump Heads

ONE of a range of head gears for driving deep-well reciprocating pumps, which has been evolved by the Moss Gear Company, Ltd., of Tyburn, Birmingham, is represented in the accompanying engraving.

As will be gathered from the picture, it is intended to convert the high-speed rotary motion of an electric motor, or some such prime mover, into a comparatively slow



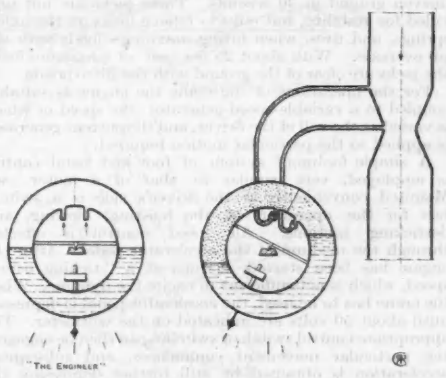
DEEP-WELL PUMP HEAD

reciprocation of the pump rod. The speed reduction is effected by a worm gear, of which the worm is made of 3 per cent. nickel steel, which is given a glass-hard surface by heat treatment. The threads are ground after having been cut and hardened, and are finally buffed to give them a polish. The worm wheel has a cast iron centre, on to which there is shrunk and pegged a chilled phosphor bronze rim. The teeth are generated in this rim by a hobbing process. The worm shaft runs in ball bearings, and that of the wheel, which is also the crank shaft for working the walking beam, runs in anti-friction bronze bushes. The gear runs in an oil bath, and is enclosed by a sheet steel casing, which is not shown in the engraving.

A Differential Pressure Gauge.

A NEW form of pressure gauge, embodying a well-established principle, has recently been brought out by Elliott Brothers (London), Ltd., of Lewisham, in the form of the Siemens ring balance meter.

As will be seen from the accompanying diagram, the moving part of the meter comprises an annular drum, which is mounted at its centre on knife edges and is



OPERATION OF DIFFERENTIAL PRESSURE GAUGE

ballasted by a weight at the bottom. It is half-filled with a liquid, which is chosen according to the nature of the service. Should it be gas pressure that is to be measured, either oil or water is used, or if it is a matter of water pressure, mercury is employed. In the first case, the drum is made of brass, but with mercury it is of solid-drawn steel tubing. The space above the surface of the liquid is divided by a diaphragm and the two compartments thus formed are connected with the sources of the pressures to be measured by flexible piping. It will be seen that if these pressures are different the liquid will be displaced and the drum will swing from its original vertical position. In other words, the pressure difference will act on the diaphragm, using the liquid as an abut-

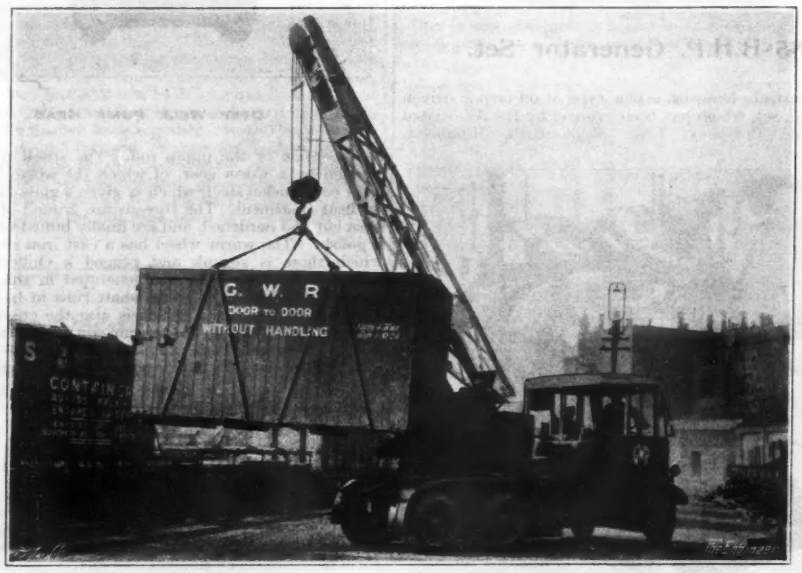
ment to turn the drum, and the angular displacement is a measure of that difference. For the measurement of a simple pressure one of the compartments only would be used, and the other left open to the atmosphere, while for the measurement of a flow the two compartments would be connected up to a Venturi throat, or an orifice plate, as shown in the diagram. For a pressure range of 6in., water gauge, and a sheet brass drum, the actual working pressure at the instrument may be 7 lb. per square inch, but with the steel drum and mercury filling a range of 100in. and a working pressure of 150 lb. can be accommodated. It is obvious that the openness of the scale on which the readings are taken, is dependent upon the magnitude of the ballast weight.

The meter has the merits that it is very sensitive to small differences of pressure and has few moving parts. It is also adaptable as a recorder when combined with a clockwork mechanism and chart.

A Mobile Crane.

THE accompanying engraving illustrates a vehicle recently made by John I. Thornycroft and Co., Ltd., of Smith-square, London in conjunction with Ransomes and Rapier, Ltd., of Ipswich, to the order of the Great Western Railway. It consists of a Thornycroft rigid six-wheeled forward control 12-ton chassis, fitted with the maker's standard four-cylinder 82 h.p. oil engine, and specially constructed to carry the Ransomes and Rapier crane. The crane base is of rolled steel sections and plates arranged to suit the chassis and to support the rack roller path and centre post.

To avoid overloading of springs, axles, and tires, supports or jacks are fitted between the rear wheels on each side. These supports are cross-braced to the chassis frame, and are arranged with their feet set at a predetermined height above the ground. On picking up maximum loads with the jib over the side, the jack on that side comes down on the ground, but on slewing the load round till the jib is in line with the axis of the lorry the jack then comes clear of the ground and the crane can travel with the load at a speed of 2 m.p.h. A simple adjustment is fitted to enable the jacks to operate correctly when the ground between the rear wheels is uneven. The jacks can be set to suit



MOBILE CRANE AT WORK IN GOODS YARD

uneven ground in 30 seconds. These jacks are not provided for stability, but only to relieve loads on the axles, springs, and tires, when lifting maximum loads with the jib overside. With about 25 per cent. of maximum loads the jacks are clear of the ground with the jib overside.

For the operations of the crane the engine is suitably coupled to a variable-speed generator, the speed of which is varied at the will of the driver, and the current generated is applied to the particular motion required.

A simple foolproof system of foot and hand control is employed, very similar to that of a motor car. Mounted conveniently at the driver's side is a switch-box for the operation of the hoisting, slewing, and derricking motions. All speed control is effected through the medium of the accelerator pedal. After the engine has been started, it runs at a "ticking over" speed, which is not sufficient to excite the dynamo. When the crane has to be used, the accelerator pedal is depressed until about 50 volts are indicated on the voltmeter. The appropriate control switch or switches can then be engaged, the particular movement commences, and subsequent acceleration is obtained by still further depressing the accelerator pedal. If the crane is hoisting at full speed, and it is desired to perform another motion simultaneously, the accelerator pedal should be momentarily released and the appropriate switch engaged when the accelerator pedal can immediately be depressed again to give the required speed, the whole arrangement corresponding very closely to changing gear on a motor car. The control system is the subject of a patent.

The revolving portion of the crane consists of a bed-plate, to which is bolted a structural steel braced frame. A substantial cross shaft at the top of the frame affords pivot mounting for the cantilever jib. The jib is constructed of steel sections rigidly cross braced. The bed-plate is arranged with a suitable bearing to receive the centre post. The hoisting and derricking motions are performed by means of separate motors driving barrels through worm and spur reductions. The slewing motion is performed by means of a motor driving the main pinion, which engages with the rack through worm and spur reductions.

The following table gives some figures and dimensions not already mentioned :—

Lifting capacity of crane	6 tons at 9ft. 6in. radius 1¾ tons at 16ft. 7in. radius
Height of lift—	
At minimum radius ..	21ft. from ground to hook
At maximum radius	10ft. from ground to hook

Speeds.

Derricking ..	Maximum to minimum radius (light), 7 sec.
Hoisting ..	6 tons at 23ft. per min. 2¾ tons at 45ft. per min.
Slewing ..	1½ revs. per min.
Travelling ..	With maximum loads and jib in line with axis of lorry, 2 miles per hour Without load and jib along axis of lorry, 20 miles per hour

General Dimensions.

Overall length	22ft. 6in.
Overall width	7ft. 6in.
Overall height (with jib horizontal)	14ft. 6in.
Wheel base (from front axle to centre of rear bogie)	14ft. 3in.
Ground clearance	7in.
Tail radius of superstructure	5ft.
Approximate load on jack	5 tons
Total weight of machine	18¼ tons
The vehicle can be turned without reversing in a road about 60ft. wide.	

THE INSTITUTION OF CHEMICAL ENGINEERS.

DURING 1934 the Institution of Chemical Engineers increased its membership by forty-three, the total number of names on its roll now being 803. At the ninth examination for admission to associate membership seven candidates presented themselves of whom six satisfied the examiners. On the financial side, in spite of an increased expenditure on the publication of the "Transactions," the Institution on an income totalling some £3347 concluded the year with a small surplus. The Appointments Bureau increased its activity as a result of the improved industrial conditions and succeeded in finding positions for thirty-six of the Institution members. An "Index of Experience" has been established from data supplied by individual corporate members and has already proved of considerable help in answering requests for expert assistance. Progress is being made with the preliminary arrangements for the forthcoming Chemical Engineering Congress to be held at the Central Hall Westminster from June 22nd to 27th 1936, at which the British Chemical Plant Manufacturers' Association will arrange an exhibition of chemical plant.

On Friday of last week February 22nd the Institution held its thirteenth annual corporate meeting at the Hotel Victoria, London. At this meeting Dr. A. J. V. Underwood read a paper entitled "The Historical Development of Distilling Plant" in which the use and design of stills for all purposes was traced from the days of the early alchemists onwards. On the evening of the same day the Institution held its annual dinner under the chairmanship of the retiring President Mr. William Macnab. Over two hundred members, ladies and guests attended the function. Lord Macmillan of Aberfeldy, in a characteristically able and humourous speech, proposed the toast of "The Institution of Chemical Engineers" to which Mr. Macnab responded. The toast of "Our Guests" was entrusted to Dr. Herbert Levinstein, the President-elect and was acknowledged by Air Marshall Sir Hugh Dowding, Professor Jocelyn Thorpe and Mr. B. Mouat Jones the Principal of the Manchester College of Technology. The proceedings concluded with the toast of "The President" given by Sir Alexander Gibb, and Mr. Macnab's response.

THE report that an attempt is to be made to enter the Gresford pit for the first time since the disaster last September has been officially denied.

Worm Gear Performance.*

By HENRY E. MERRITT, D.Sc. (Eng.), M.I.Mech. E.†

THE term "performance" applied to any piece of power transmission mechanism may be regarded as embracing load-carrying capacity and efficiency. The purpose of the paper is to discuss the considerations which determine or influence the performance of worm gears and to show their application to design practice.

Of fundamental importance is the question of load-carrying capacity; the size, weight, and first cost of any gear unit depend entirely upon accurate design data. The basic principles governing load-carrying capacity are applicable to most types of toothed gear, and the line of approach to the design problem outlined in the paper has been embodied in British Standard Specifications No. 436—1932 (Spur and Helical Gears), No. 545—1934 (Bevel Gears), and in a forthcoming specification for worm gears. To the last-mentioned specification this paper may be regarded as a supplement.

It should be clearly stated that in the methods and data which follow there is much that is empirical. Quantities which did not appear to lend themselves to analytical determination have been the subject of experimental work and observations on gears in service. It is hoped that by indicating what is empirical and what is still unknown, the ground will be cleared for further work.

Worm Thread Form.—Any analysis of worm gear stresses and tooth friction will naturally be based on the assumption that the worm threads and wheel teeth are accurately produced and accurately meshed, whilst in evolving design methods to cover the whole range of practical requirements it is necessary to adopt methods of detail design which, even if they do not result in optimum contact conditions in every case, at least avoid any risk of serious error or defect, such as loss of contact by interference or undercutting or excessive relative curvature. For these reasons, it is necessary to discard the accepted form of worm thread, which is straight-sided on the axial section, and to seek a thread form which is at once easy to produce with accuracy, gives the necessary flexibility of design to cover the requirements of different ratios, and is more amenable to analytical treatment of contact conditions. These requirements are met by the involute helicoid (universally employed for helical and spiral gears), and this form will be the recommended practice for worm threads in the forthcoming British Standard Specification for worm gears.

All the data given in the paper apply to gears in which the worm threads are of this form.

The Involute Helicoid.—The involute helicoid is, as its name implies, a helicoidal or screw surface such that on any transverse section the profile is the involute of a circle concentric with the axis of the surface. Such a surface has peculiar and valuable properties. It may be described by a straight line which traces out a helical path, the condition being that the generating straight line is a tangent to a helix having a lead equal to that of the surface to be produced.

Thus in Fig. 1 X X represents the axis of a helix A B, of lead L and diameter d_o. If a straight line C D, tangential to the helix at C, describes a helical path of lead L,

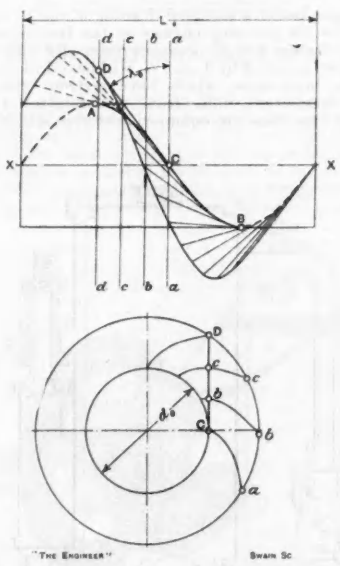


FIG. 1—*Generation of an Involute Helicoid.*

it will generate an involute helicoidal surface. This surface is composed of all the successive positions of the generating line.

The lead angle of the helix A B will be λ_o, such that

$$\tan \lambda_o = L/\pi d_o$$

and the quantities d_o and λ_o completely determine the surface. They are termed "base diameter" and "base lead angle" respectively.

On a transverse section *a a* passing through C, the profile of the surface will be a curve C *a*, which is an involute to the base circle of diameter d_o. On other sections *b b*, *c c*, *d d*, the profiles will, of course, be similar, but will be displaced by angular amounts corresponding to the axial displacement of the plane of section.

Since C D in end elevation is a tangent to the base circle, it will be normal at the point of contact to any involute which it crosses. Hence a plane can be made to touch the involute helicoid along its generating straight line, or, alternatively, the helicoid can be generated by a

* The Institution of Mechanical Engineers—February 22nd.

† Assistant Chief Engineer, David Brown and Sons (Huddersfield), Ltd.

plane, so disposed as to contain the line C D, the normal plane containing C D being parallel to the worm axis.

When viewed in a direction perpendicular to the axis, the line C D actually represents the outline of the thread, and the plane which generates the thread is also represented by this line.

Referred back to practice, this means that a worm having a thread form of this kind may be finish-ground by a flat-sided abrasive wheel (which is the easiest to make and maintain accurately) and may be measured by a gauging point moving along the straight line C D.

Detail Design.—It is necessary to indicate briefly the limitations to the values of $d_\circ$ and $\lambda_\circ$ in working out detail design as a preliminary to a study of tooth contact and stresses.

In order that the whole of the effective surface of the worm may be provided by the one involute helicoid, the base diameter should not exceed the root diameter by more than a small amount, sufficient to embrace the root clearance (see Fig. 2*a*). It can, however, be made as much smaller as is compatible with a reasonable normal section

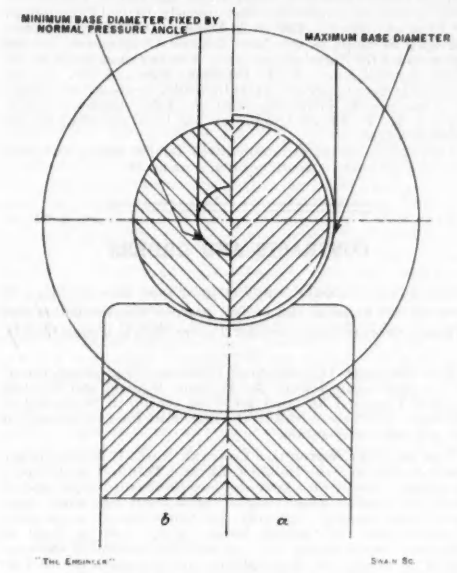


FIG. 2—*Limitations of $d_\circ$ and $\lambda_\circ$.*

of worm thread. Thus the case shown in Fig. 2*b* may hold good for a single-start worm. The higher the lead angle, the more nearly must the base circle approach the root of the worm.

A useful criterion is obtained by fixing the "normal pressure angle." This is the apparent inclination of the sides of the threads when viewed in the direction of a tangent to a nominal "pitch helix"; incidentally, the sides of the threads appear straight over a wide range of direction of view.

Thus if the diameter of the threads on a nominal pitch diameter is d, the lead angle on this diameter will be

$$\lambda = \tan^{-1}(L/\pi d).$$

Viewed at this angle λ, as in Fig. 3, the threads will

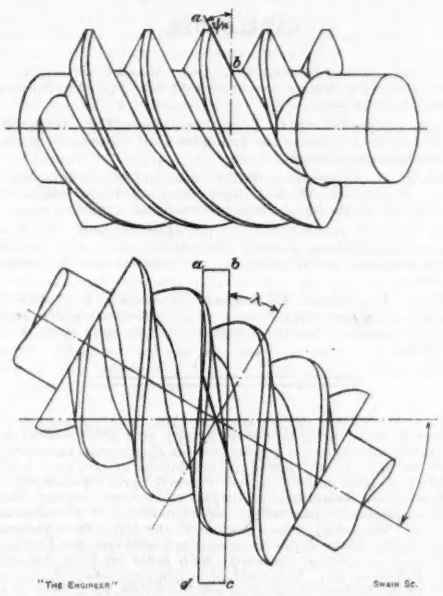


FIG. 3—*Apparent Inclination of Side of Thread.*

have an apparent inclination of ψ_n, the normal pressure angle. A contact plane, parallel to the direction of view, is represented by $a\ b\ c\ d$, and the inclination of this plane will be related to the base lead angle by

$$\cos\lambda \cos\psi_n = \cos\lambda_\circ.$$

Thus, given λ and ψ_n (the value of the latter being between 20 deg. and 25 deg.), $\lambda_\circ$, and thence $d_\circ$, may be determined.

The axial section should be verified. This may be done by calculating the rectangular co-ordinates, which in terms of an independent variable θ are

$$x = L(\tan\theta - \theta)/2\pi$$
$$y = (d_\circ \sec\theta)/2$$

the axis of x being the axis of the worm.

Zone of Contact.—Contact between any two gears, one of which generates or may be regarded as generating the other, always occurs along a line or lines. The first step in the problem of determining load-carrying capacity consists in finding the position of the contact lines at every phase of engagement.

The successive positions of all the lines of contact over the whole period of engagement will form a surface called the "zone of contact," and at any instant the lines of contact will be represented by the intersection of the zone of contact with the surface of the teeth or threads of either member.

The general analytical solution is too complex for everyday practical use, but fortunately the property of the involute helicoid, that it has a tangent plane along its generating line, leads to a very simple way of determining the zone and lines of contact, either by a graphical method which is both quick and accurate, or by a simple though more laborious analytical counterpart.

Certain fundamentals must, however, first be established. A pair of spur gears has two easily visualised pitch surfaces, namely, two pitch cylinders which roll together. In the case of worm gears, in which the threads of the worm are helical, the worm corresponds to a rack, since pure translation in the direction of its axis gives the same apparent motion as does its actual rotation. The pitch surfaces thus become a cylinder for the wheel and a plane for the worm, and are illustrated in Fig. 4. In this

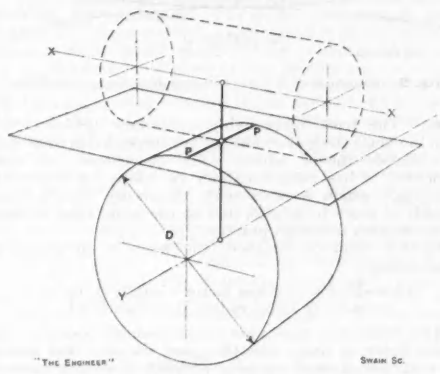


FIG. 4—*Pitch Surfaces of Worm and Wheel.*

diagram X X and Y Y are the axes of the worm and wheel; the pitch cylinder of the wheel has a diameter D equal to T m, where T is the number of teeth and m the module, and the pitch plane of the worm is the plane, parallel to its axis, which touches the wheel pitch cylinder. The position of this plane has nothing to do with the dimensions of the worm; the diameter of the cylinder coaxial with the worm, which touches the wheel pitch cylinder is sometimes referred to as the "worm pitch diameter," but this cylinder is not a true pitch surface.

Contact between the two pitch surfaces occurs along the line P P, called the pitch surface generator, and the fundamental condition of contact is that at any point of contact the common normal to the surfaces must pass through the pitch surface generator.

Zone of Contact of Involute Helicoid.—On the foregoing as basis, the method of determining the zone of contact for an involute helicoid worm in mesh with a wheel is as follows:—

In Fig. 5, let X X be the axis of the worm, P_1 P P_1 the pitch surface generator, and let the base dimensions $\lambda_\circ$ and $d_\circ$ be known. Let a transverse involute to the base circle be drawn through P. This is the initial point of contact.

Now on any plane section tangential to the base cylinder the thread surfaces will be straight-sided. Let such a section be A B. Then it is merely required to find at what point a perpendicular to a line inclined at $\lambda_\circ$ in this plane will intersect the line P_1 P P_1; this point is a point of contact for the given angular position of the worm.

In the auxiliary view 4 (not required in the actual construction) the line C D represents the generating line as in Fig. 1, inclined at $\lambda_\circ$ to P P, whilst point a, by construction, lies in the vertical plane containing P P. The normal to the thread surface will intersect P P in b or b_1; hence the foot of the normal, *i.e.*, the point of contact, is at $c = c_1 = c_2$.

Now the position of the point is determined by the length $a_1 b_1 = a\ b =$ the intercept between the pitch plane and the initial involute. Thus x, the distance of the point of contact from P_1 P P_1 in the direction of the axis of the worm will be

$$x = a\ b \sin\lambda_\circ \cos\lambda_\circ = (a\ b \sin 2\lambda_\circ)/2.$$

The distance $b\ c$ (view 2) will be

$$b\ c = a\ b \sin^2\lambda_\circ.$$

Thus the point of contact always divides the intercept $a\ b$ in a constant ratio, and the axial displacement is also proportional to the intercept. From these two dimensions the point of contact may easily be set graphically.

If it is desired to calculate the co-ordinates, they are as follows:—

$$x = (a\ b \sin 2\lambda_\circ)/2,$$
$$y = a\ b \sin^2\lambda_\circ \sin\theta,$$
$$z = \text{P}\ b - a\ b \sin^2\lambda_\circ \cos\theta,$$

in which

$$a\ b = \cot\theta\,(h - r_\circ\cos\theta) - [h\sin\psi_t - r_\circ(\psi_t - \theta)]$$

and

$$\text{P}\ b = \cos\theta\cot\theta\,(h - r_\circ\cos\theta) - r_\circ\sin\theta.$$

The adjacent thread, if within the zone of contact, will have a point of contact also in the line $b_1\ c_1$ at a point d_1 distant $p_\circ = p\cos\lambda_\circ$ (where p is the axial pitch) from c_1. The distance $c\ d$ will be equal to $p_\circ \sin\lambda_\circ = (p \sin 2\lambda_\circ)/2$. If the points $c_2\ d_2$ be drawn and joined (view 3) the successive lines of contact for successive fractions of a pitch of

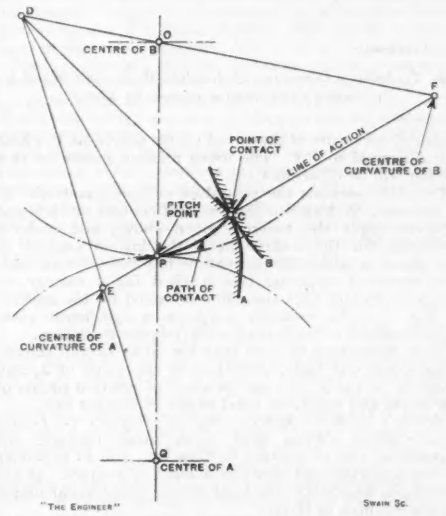


FIG. 6—*Centres of Curvature of Tooth Profiles.*

movement of the worm will be equally spaced; this makes it easy to fill in intermediate lines of contact and the boundary of the zone. The zone of contact consists of straight lines similar to $c_2\ d_2$, *i.e.*, it is a ruled surface.

Relative Radius of Curvature.—From the zone of contact the minimum length of contact line may easily be determined by direct measurement of the lines of contact for

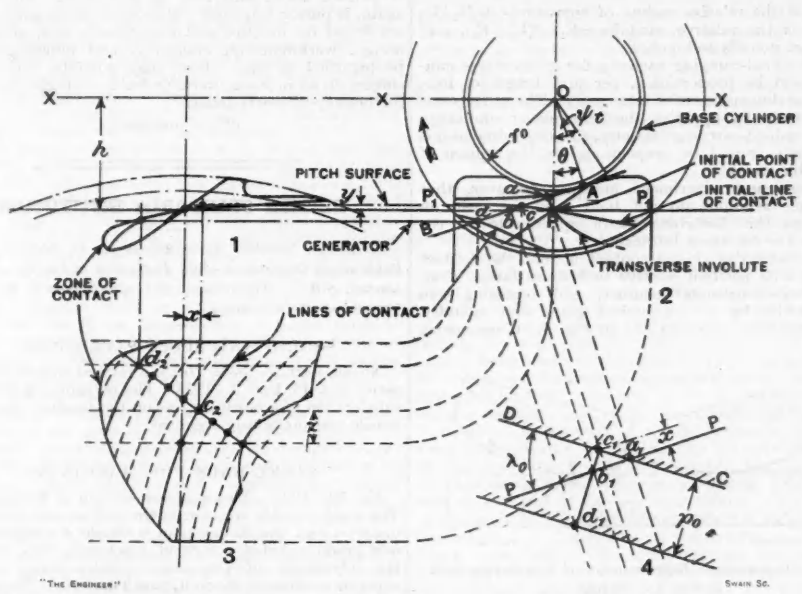


FIG. 5—*Determination of Zone of Contact for Involute Helicoid Worm and Wheel.*

various angular positions of the worm. The next problem is: how much load-carrying capacity has each unit length of line?

The first step is the determination of relative radius of curvature, and may be prefaced by a theorem.

If two tooth profiles, rotating about centres O and Q (Fig. 6) make contact at a point C, then the lines drawn from the intersection of (*a*) the normal to the line of action at the pitch point and (*b*) the normal to the path of contact at the point of contact, when produced through the centres O and Q, will intersect the line of action in the centres of curvature of the profiles. There is probably an extension

of this to three-dimensional contact, if someone will work it out; meantime, the two-dimensional method can be applied to any axial section of a worm, and to one section of an involute worm with considerable exactness, namely, the section containing the fundamental straight line.

On this section, the path of contact (the intersection of the zone and the plane of section) is a straight line and the radius of curvature of the worm profile is infinitely great; hence the radius of curvature of the wheel tooth profile represents at the same time the relative radius of curvature in a direction substantially normal to the line of contact.

Thus in Fig. 7, taking the plane C D as before, the path of contact will be the line P I inclined at λ_o to the axis. The

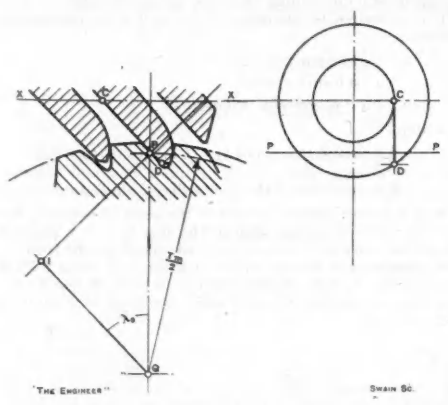


FIG. 7—*Relative Curvature of Involute Worm and Wheel on a Section Containing a Generating Line.*

centre of curvature of the wheel profile will be at I, where Q I is normal to P I. The mean relative radius on this section will be $(T\,m \sin \lambda_o)/2$.

On other sections the procedure is more involved. It is necessary to draw out the paths of contact on different sections, apply the theorem given above, and make a correction for the inclination of the line of contact to the plane in which the curvature has been determined. The result of applying this method for a variety of designs indicates that the value obtained by the method of Fig. 7 is, for ordinary purposes, a sufficiently close approximation to the general mean relative curvature.

It is interesting to note that for given overall dimensions, pitch and ratio, variations in the value of λ_o still result in a nearly constant product of relative radius of curvature and minimum total length of contact line.

Stress Conditions Between Curved Surfaces in Loaded Line Contact.—When gear teeth make contact, the theoretical line of contact flattens out due to elasticity of the materials and becomes a band of contact. If the conditions were static, the local stresses could be calculated by the methods of Hertz.

Thus, if two curved surfaces, radii R_1 and R_2, in materials having moduli of elasticity E_1 and E_2 make contact along a line of unit length, and are loaded with a force P, the maximum stress would be:

$$S = 0{\cdot}418\sqrt{\frac{P\,E_r}{R_r}}$$

and the width of the band of contact:

$$b = 3{\cdot}04\sqrt{\frac{P\,R_r}{E_r}}$$

where R_r is the relative radius of curvature $= R_1R_2/(R_1+R_2)$, E_r is the relative modulus $= E_1E_2/(E_1+E_2)$, and the units are pounds and inches.

Thus, the load-carrying capacity for given stress conditions would be proportional, per unit length of line, to the linear dimensions of similar gears. The same result follows directly by applying the principle of similarity. Further, the load-carrying capacity, for given dimensions and elasticity, would be proportional to the square of the allowable stress.

Experience and experiment indicate, however, that these simple relations do not hold good for gears in motion, and the disturbing factor appears to be the presence of the necessary lubricant.

The characteristic of line contact is that the contact line changes its position relative to both surfaces. Considering two-dimensional contact, and replacing two curved profiles by the equivalent plane and cylinder, the conditions are as illustrated in Fig. 8. Commencing

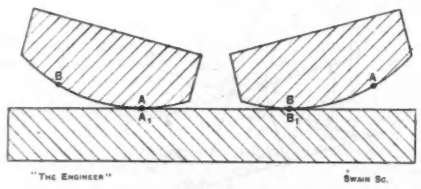


FIG. 8—*Diagrammatic Representation of Two-Dimensional Rolling and Sliding.*

with contact at A and A_1 combined rotation and translation results in subsequent contact at B and B_1. During this time, the total amount of sliding which has occurred is A B and A_1B_1 (measured along the surfaces), while the amounts of rolling are A B and A_1B_1 for the respective surfaces. The effect of these combined motions is to bring newly lubricated surfaces into action, and lubricant will tend to be drawn between the surfaces either by viscosity or by "oiliness" (whatever that may really be). This tendency will be greater as the rolling action increases in relation to sliding; thus, if in Fig. 8 the direction of angular motion of the moving element were reversed, the sliding effect would diminish, and when A B = A_1B_1 pure rolling occurs. Conversely, if A B = A_1B_1, the viscosity drag effect disappears and only oiliness remains.

Under all ordinary conditions of worm gear contact, pure rolling never occurs, neither are the rolling components equal and opposite, and a tentative suggestion regarding what actually happens is that there exists between the surfaces an oil film under high pressure, composed partly of a boundary layer between those portions which would make static contact, plus a hydrodynamic film of diminishing pressure, drawn in by viscosity, represented by Fig. 9.

Whatever the nature and extent of the pressure variations caused by the presence of oil, a linear relation between dimensions and loading for a given maximum pressure will no longer apply. According to the late Mr. H. M. Martin, M.I. Mech. E., the assumption of non-elastic materials and load carried entirely by a hydrodynamic film leads to the result that the load-carrying capacity increases as the square root of the linear dimen-

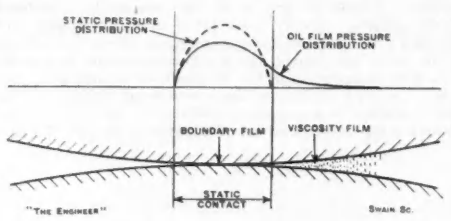


FIG. 9—*Hypothetical Pressure Distribution Due to Oil Film.*

sions. The truth is probably somewhere between the two, but since the author has not yet succeeded in evolving a workable theory which would incorporate all the variables, it has been necessary to adopt an empirical treatment which accords with laboratory results and records of gears in service, and at the same time is easy of application to design practice.

In this empirical method, the basis is an assumed relationship:

$$\text{Allowable load} = \text{stress factor} \times \text{length of line of contact} \times (\text{relative radius of curvature})^{0{\cdot}8}.$$

The index 0·8 represents a compromise between the static index of unity and the pure viscosity film index of 0·5; the effect of viscosity at different relative surface speeds is partly offset by the customary use of more viscous oils at lower speeds. It does not take into account the difference in tooth motion with different lead and pressure angles, since, although it is known from experiment that the higher the rolling velocity the greater the load required to cause failure, sufficient quantitative data have not yet been obtained.

The stress factor, it was found, had to be determined experimentally; the factors for different materials bear little or no relationship to the physical properties under static tests. The disturbing factor again appears to be the lubricant, and its greater affinity for some materials than for others, for although the stress factors used for the usual combination of hardened steel and phosphor bronze represent the limit before "pitting" (a fatigue shear failure) occurs, this is possible only because these materials permit the oil film to be sutained. Materials less favourable to the maintenance of an oil film, such as steel and steel, fail by breakdown of the oil film, and consequent scoring or wear before failure in the body of the material can occur.

The stress factor used in design is found by multiplying a "basic stress factor" appropriate to the combination of materials by a "speed factor" combining the effect of surface speed and rate of repetition. This factor, again, is purely empirical; the values given subsequently are based on practice and experiment, and, given good design, workmanship, mounting, and lubrication, may be regarded as safe. They may possibly, however, be subject to an increase, more probably at higher speeds, as further experience is gained.

(To be continued.)

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

SOLID AND SPLIT TAPER PINS.

No. 46, Part 3—1935. This is a revised edition of specification No. 46, Part 3—1935. The revision consists in the substitution of a hardness test on the finished pins for the tensile test previously specified.

STEEL BARS FOR MACHINING.

No. 32—1935. This is a new edition of B.S.S. No. 32. The most notable revision is the withdrawal of Grade 3 material and the inclusion of a Grade 4 material. The new grade included is a rapid machining steel which has the advantage of possessing shock-resisting qualities superior to those of the old Grade 3 material. The qualities of the new material are so different from the old Grade 3 that the Committee felt it would be unwise to call it a new Grade 3, and accordingly Grade 3 has been withdrawn.

VITREOUS-ENAMELLED STEEL REFLECTORS FOR ELECTRIC LIGHTING.

No. 232—1935. The Committee responsible for the preparation of the B.S. Specification for Industrial Reflector Fittings for Electric Lighting, No. 232, which was issued in 1926, has just revised this specification.

The chief modification is in Clause 6, dealing with distribution of light. Instead of specifying the distribution of light from the reflector and lamp as a ratio of the maximum candle-power in any direction within 15 deg. of the downward vertical axis to the average of the candle-powers at certain angles, it is stated that it shall comply with the requirements of B.S.S. No. 398 (*a*) III, which is the intermediate class of the direct class of lighting in the British Standard Classification of Light Distributions. A column giving the nominal lumens of the lamp has also been added to the table, and it is required that in cases in which the polar curve of light distribution is given, the candle-power values shall be those resulting from the use of lamps whose output in lumens is in accordance with this column.

THOMAS GRAY MEMORIAL TRUST.

THIRTY-THREE entries were submitted for the Inventions Prize under the Thomas Gray Memorial Trust, administered by the Royal Society of Arts.

In view of the fact that three of the inventions submitted possessed, in the opinion of the judges, distinct merit, while none of them sufficiently stood above the rest to receive the whole award, the judges have unanimously decided to apportion the Prize as follows:—£50 to A. Lansley, D.Sc., Extra Master, Surveyor of Ships to the New Zealand Government, for his stress finder for Ships' cargo gear; £25 to Commander H. D. Warburg, R.N., and A. T. Doodson, D.Sc., F.R.S., of the Liverpool Observatory and Tidal Institute, for their new method of approximately predicting tides and tidal streams; £25 to Captain H. E. Lloyd Owen, for his binocular-compass, or "Compoculars."

Twenty-one essays were submitted for the Essay Competition, and six awards, totalling £100, were made.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

THE SINTERAE ILLUMINATING COMPANY, Southampton-row, W.C.1, has received from the London, Midland and Scottish Railway Company an order for a fog beacon to be erected at Tilbury. This beacon will be the first of its kind to be used for the purpose of navigation.

THE SUNBEAM MOTOR CAR COMPANY, Ltd., Wolverhampton, has received from the Rangoon Electric Tramway and Supply Company an order for a fleet of fifteen Sunbeam-B.T.H. electric trollybus chassis. These chassis, the M.F.3 A four-wheel type, have been designed specially for thirty-seater, single-deck front-entrance, lightweight bodies, which will be built in Rangoon. Since speeds of 20 to 25 m.p.h. cannot be exceeded owing to congested thoroughfares in Rangoon, the B.T.H. Company have found it possible to use a 35 h.p. geared traction motor of special design, and extremely light construction, which, in conjunction with suitable foot-operated control gear, provides both regenerative and rheostatic braking.

MIRRLEES, BICKERTON AND DAY, Ltd., Stockport, have recently received a number of orders including one from the Bombay, Baroda and Central India Railway Company for a six-cylinder, 720-b.h.p. "Mirrlees-Diesel" airless injection engine for installation in the Dohad power station. This station is situated at an altitude of 1050ft. above sea level, and the air temperature is 112 deg. Fah. The engine is required to work continuously under these conditions, and will therefore develop 587 b.h.p. It will be coupled to a 400-kW E.C.C. dynamo. Among the other orders are one from the Crown Agents for the Colonies for a pontoon pumping set for the Perak River, and one from the Indian Stores Department for two three-cylinder, 200-b.h.p. airless injection engines for installation at Sambhar Lake.

CATALOGUES.

NEWMAN, HENDER AND CO., Ltd., Woodchester, Glos.—Catalogue 55M, dealing in detail with the Newman Milliken lubricated plug valve.

PARSONS MARINE STEAM TURBINE COMPANY, Ltd., Wallsend-on-Tyne.—Particulars of the "Simplex Unit" system of geared turbines for cargo boats.

SIR W. G. ARMSTRONG, WHITWORTH AND CO. (ENGINEERS), Ltd., Scotswood Works, Newcastle-on-Tyne.—Publication No. 614, giving the latest range of portable air compressors.

W. WATSON AND SONS, Ltd., 313, High Holborn, W.C.1.—A booklet describing in detail photometers or density meters, which are made in two patterns—the selenium and the photo-electric.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Falcon Works, Loughborough.—A copy of a publication which deals with the range of heavy oil engines built in sizes from 30 to 800 b.h.p.

THE AVOIDANCE OF ACCIDENTS.—We have received from Alfred Herbert, Ltd., Coventry, a copy of a new publication, entitled "How to Avoid Accidents in the Engineering Industry." This booklet is only issued to employees of the firm when starting service, and has to be returned upon termination of employment. Conditions of employment, time-keeping rules, and a system for precluding impersonation, are all included therein. The safety rules are indexed and range from General Engineering Shop Rules to specialised sections for Drilling, Milling, &c., machine operators, with notes on First Aid and Skin Infection, &c. This method of bringing safety hints and rules to the notice of employees will, no doubt, be of interest to those responsible for the welfare of workers in the engineering industries.

MR. JAMES HARRINGTON.—The death occurred at his home at Harrow on February 18th, 1935, of James Harrington, in his fifty-ninth year. Mr. Harrington was apprenticed in 1889 to John Henry Storey, and was associated with the Edison and Swan Lamp Works at Ponders End for some years. In 1910 the firm of Hill and Harrington, Ltd., electrical engineers and contractors, was formed, of which Mr. Harrington was managing director. Subsequently he developed a consulting practice, and was associated in this connection with the electrical equipment of many country houses and the whole engineering lay-out of farm estates. He was consulting engineer to many of the leading London and West End drapery establishments and restaurants. He was a member of the Institute of Electrical Engineers, an associate member of the Institute of Mechanical Engineers, and a member of the Institute of Heating and Ventilating Engineers. For eighteen years he was Secretary of the London Association of Engineers, of which he was also President in 1910 and Trustee at the time of his death.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Continental Steel Trade.

The Continental steel industries are passing through a period of quiet trading, but as a result of the buying movement in the first few weeks of the year they are well situated as regards orders in hand. The French, Belgian, and Luxemburg works appear to be improving their position, largely because the German industry has agreed to the demands of the Cartel that it should withdraw from many of the export markets in order to allow other members to fill their allotments. This points to an improvement in the relations of the Continental industries, as only a short time ago there was considerable dissension between the members of the Cartel. This was caused by the methods of barter trading by which the German steel works had secured a number of important orders. Apparently the Germans have waived their claim that the tonnage obtained in this way should be excluded from the quota allotted by the Cartel. It is now reported that the German excess is being rapidly overtaken and that whilst a fortnight ago it amounted to 25,000 tons, it has since been reduced to just over 10,000 tons. Although little doubt is entertained that the Cartel agreement will be renewed this month reports are current that the French and German steel makers have disagreed over claims arising from the return of the Saar to Germany. It is reported that France is unwilling to take the proportion of the Saar production suggested by Germany. In 1933 about 29 per cent. of the Saar output was exported to France. The following year this had dropped to 19·4 per cent. A recent proposal that France should take 11 per cent. has been refused. The Germans have retorted by asking for a higher export allotment to other markets and, naturally, this provoked protests from other members of the Cartel, whose shares in the markets affected would have been reduced. Difficulties such as these disturb the market, as, naturally, buyers do not care to enter into long-distance commitments whilst there is even a remote chance that the Cartel arrangements may break down. It is generally agreed that the first result of this would be a collapse in Continental steel prices, and it is this, as much as anything, that binds the members of the organisation together.

The Pig Iron Market.

Although activity in this market does not decrease, the volume of business shows little sign of expanding. Deliveries are well maintained, and while conditions in the different districts vary to a certain extent, in general they are steady and firm. Satisfactory conditions have ruled on the North-East Coast, and if the requirements of Scottish consumers have not come up to expectations, there are indications that heavier shipments will have to be made shortly. Deliveries to local consumers also have been on an important scale. Practically the whole output of the five furnaces producing Cleveland iron is being absorbed, and occasional inroads have to be made upon the stocks in the makers' hands. Several important contracts are approaching completion, and it is expected that these will be renewed shortly. Most consumers appear to be well covered for some distance ahead, and the business which has been transacted of late has consisted principally of small parcels. Lately there has been a certain amount of inquiry for forward delivery, which, however, has not been followed up by the placing of important orders. In the Midlands the blast-furnaces are well employed, but the amount of new business reaching them leaves something to be desired. The light castings makers are not providing so large an outlet for iron as was expected early in the month, but nevertheless, it is claimed that the consumption of Midland foundry iron in February will be larger than in the first month of the year. There has been a considerable demand for superior qualities of iron from the heavy engineering industries. In Scotland the light foundries are taking good quantities of local pig iron, and, in spite of competition from outside sources, the use of Scottish brands seems to be increasing. Similar conditions rule in Lancashire, where there is a slow but steady expansion in business. A number of good contracts have been renewed recently, and others are on the point of expiring. The hematite market has been rather quieter than of late, but the works have large contracts on their books, against which specifications are freely coming to hand. Business in basic iron also has been active and in one or two cases it is reported that firms contemplate increasing their production.

The North-East Coast and Yorkshire.

The position at the works on the North-East Coast producing finished steel material is satisfactory up to a point. Good contracts are in hand and there are no complaints of the rate at which specifications are coming forward. On the other hand, the amount of new business reaching the steel works has been rather limited and the individual orders with a few exceptions have been on the small side. Large orders have been placed by Russia, and some useful contracts have been received from India and China, the latter including one for a new bridge, which has been taken by Dorman, Long and Co., Ltd. Although business is reported to have been rather more active in sheets, the mills are not well occupied. The demand is principally for medium and heavy gauge sheets on home account and the export trade in light sheets is still poor. The rail mills are moderately busy and anticipate fresh work being given out in the near future. Recently also the works producing shipbuilding steel have received a fair tonnage of orders and are making better deliveries to the shipyards than for some time. The requirements of structural engineers have diminished somewhat, but this is probably because a number of firms have placed forward contracts. This industry is in a good position as regards orders in hand, and it is also expected that a fair amount of new work will come on the market shortly, so that the lull in the demand for joists and sections is regarded as only temporary. The Yorkshire steel industry is steadily employed, although some of the rolling mills are not making such good outputs as in December and January. There is a heavy production of basic steel by the Sheffield works, and for the time being there seems little likelihood of any noticeable decline. The position is not so good in the acid steel section, but lately there has been some increase in the demand for acid carbon steel billets. These are quoted at from £7 10s. for up to 0·25 per cent. C. to £11 7s. 6d. for 1·5 to 2 per cent. C. Most of the Sheffield toolmakers are busily employed, but as they have covered their forward requirements for some time the amount of new business in tool steel has declined. The users of special steels show a well-sustained interest in the market and there has been no appreciable decline in the demand for stainless steel.

Scotland and the North.

Satisfactory conditions continue to rule in the Scottish steel industry. The works are making good deliveries to the shipyards, and the orders placed recently for new ships should make up for contracts which are being completed. If there is any balance on the wrong side the current contracts which have been taken by the Scottish engineering concerns should suffice to fill the gap. Most of the Scottish bridge-building firms are busy and a considerable tonnage of steel is finding its way into consumption through this industry. The position at the tube works is not altogether satisfactory, but there is a good volume of inquiry circulating, a large proportion of which it is anticipated will result in orders. There is a steady demand on home account for heavy and medium gauge sheets, but comparatively little business is passing in the lighter sorts. The Scottish re-rollers are amongst those branches of the industry which have suffered most severely from Continental competition, and are looking forward to a considerable improvement in trade if the duties are increased. Even the possibility of the duties being raised has benefited them to the extent that buyers of Continental material have been chary of placing orders abroad whilst the position is uncertain, with the result that more business has gone to the Scottish re-rollers. Even so, however, there is a good deal of broken time at the mills. The steel market in Lancashire has been rather apathetic, and the belief that an expansion in the demand for steel would occur during the first quarter of the year is beginning to fade. Heavy sections have been in steady request, but new business in ship and boiler plates has been particularly light. Fair quantities of structural steel are passing to the constructional engineers, and there seems little expectation in this district that prices will be revised in an upward direction. The demand for special steels is well maintained, and bright drawn steel has been in fairly active request. On the North-West Coast the steel makers complain of the scarcity of orders. Most of them have plenty of work in hand, however, and there seems little likelihood of operations in this district declining for some time. A considerable tonnage of semi-finished steel is being turned out, and lately deliveries have been on an exceptionally heavy scale.

Current Business.

It is announced that orders for machine shop equipment valued at £200,000 will be placed with British firms by the Chinese Government Purchasing Commission. Last year the contracts placed by the Commission in this country were valued at £1,849,979. The Fairfield Shipbuilding and Engineering Company, Ltd., of Glasgow, has made the lowest offer for the building of two destroyers for the Greek Government. Dorman, Long and Co., Ltd., have taken the order for a sixteen-span bridge across the Chien Tang River in China, which will involve the use of 4516 tons of steel. The Admiralty has placed a contract for a caisson for the Singapore Dock with Sir William Arrol and Co., Ltd. The Blue Star Line has placed a contract with Cammell Laird and Co., Ltd., of Birkenhead, for the hull of a 12,000-ton refrigerated motor ship. Miller and Co., Ltd., engineers and ironfounders, of Edinburgh, have completed an order for Walmsleys (Bury), Ltd., for an eight-roll calender stack of 133 tons 10 cwt. It is claimed that this is the largest stack of paper machine calender rolls ever manufactured and that when completed the machine in which the rolls will be used will be the largest and widest in the world. The order was taken in the face of keen German and American competition The Department of Overseas Trade announces that the following contracts are open for tender :—Latvian Ministry of Agriculture : ungalvanised wire ropes for dredgers (Riga, March 1st) ; Australia : State Electricity Commission of Melbourne : hard-drawn copper conductors, jointing sleeves and 3/0 s.w.g. hard-drawn copper grooved trolley wire (Melbourne, March 18th) ; Siam, Royal State Railways : semi-automatic wheel lathe (Siam, May 10th) ; South African Railways and Harbours Administration : about 161 tons of steel bridge work (Johannesburg, April 1st) ; Argentine State Oilfields : Diesel-driven locomotive for Decauville track of 60 cm. gauge ; five horizontal duplex pumps, petrol driven, for cementing oil wells (Buenos Aires, March 22nd) ; Diesel motors—vertical four-stroke—16 and 175 to 200 h.p.; 3283 mild steel seamless tubes for ammonia interchangers ; 1320 seamless Admiralty metal tubes for interchangers, and 360 steel and copper tubes for recording thermometers (Buenos Aires, March 20th). The Department of Overseas Trade has received an inquiry from a firm in Canada for 18-G. black steel barrel sheets in two sizes, 25¾in. by 103in. and 36¼in. by 7⅜in. A local firm at Los Angeles requires quotations for 300,000 lbs. of steel sheets for the manufacture of electrically-welded water heaters and range boiler tanks and 3in. O.D. tube of ·125 minimum wall thickness cut to lengths of 31in., 37in. and 43in.

The Copper Market.

The hopes entertained at the beginning of the year that the copper market would recover from the depression that had ruled for so long seem likely to be disappointed. Fresh weakness has developed and the price for electrolytic at one time fell below £30. The poor demand is not in itself sufficient to account for the downward movement, since there has been little variation recently in the requirements of the market. Probably more than one factor has played its part. Disappointment at the slow progress made towards agreement between the producers to restrict production and the consequent realisation of metal held for a rise ; heavy offerings by American producers on a market which was obviously inclined to mark time ; and last, but not least, the tightening of the Italian import restrictions, have all had their effect. It is said that the negotiations between the producers are proceeding, but there is a significant lack of detail and the market has become frankly sceptical. The prospect of the curtailment of Italian copper imports is regarded with concern, as Italian consumers have been taking good quantities, and it was expected that they would continue to do so for some time, as they were supposed to be short of stocks. Little of interest has transpired in the London standard market. Prices have receded and in the absence of support the contango has widened to a more normal figure. American statistics show some improvement in the copper position. The world's stocks of refined copper on January 31st are given as 487,900 tons, compared with 642,200 tons at the end of January, 1934. The stocks in North and South America showed a reduction of 16,000 tons during January to 355,200 tons, but elsewhere increased by 9000 tons to 132,600 tons. In mid-week prices became a little firmer, but according to reports from America the prospects of the producers reaching an agreement seem somewhat remote. The view seems to be that the attitude of the producers in Africa and Chile who require a larger quota than the producers in the United States are inclined to give them stands in the way of an arrangement being reached.

Tin.

The heavy decline in values in the tin market during the past few days created some surprise, since, so far as can be seen, no attempt was made to check the fall by the group which is usually regarded as being associated with the tin control. By mid-week, compared with a week ago, values in this market had shrunk £12 to £13 per ton, although apparently there has been no change in the fundamental situation from that which has existed for some months past. The uncertainty created by the decision of the International Tin Committee not to fix an allotment figure for the second quarter of the year until March 14th was not in itself sufficient to account for the movement. Offerings of the metal, too, although substantial in character, were not more than the market might reasonably have been expected to absorb. The principal change in the position would seem to be the withdrawal of support, and it remains to be seen for how long this state of affairs will continue. It is possible, of course, that the political attacks upon the tin restriction scheme may have had some effect upon the market, although it is not easy to see how the situation can be altered so long as the international control scheme remains in force. The demand from consumers has been quiet, and neither America nor the Continent has shown much interest in the market. For the time being interest in the market seems to be centred upon the demands for information regarding the operations of pools which it has been generally believed have existed almost as long as the International Tin Committee. It is rather ironical that it needed a crisis in other commodity markets to draw attention to operations which have been going on in the tin market for so long.

Lead and Spelter.

The position in the lead market remains sound, although the price of the metal is generally regarded as being very cheap. Some of the Mexican lead which recently arrived in this country has been put into warehouse ; but a fair tonnage is reported to have been re-exported to Italy. In Great Britain consumption has been on a satisfactory scale. There is no relaxation in the demand from the pipe and sheet makers, whilst the cable makers have shown more interest in the market than for some time past. American reports indicate that the market there has greatly improved since the Supreme Court's decision upon the gold-dollar clause and that buying has been active on the part of all the consuming industries. Some improvement was disclosed by the American figures for January. The stocks at the end of that month were reported as 232,000 tons, compared with 235,000 short tons at the end of the previous month. The January output was 30,700 tons, compared with 37,200 tons in December. . . . Conditions in the spelter market have shown little change. Anticipations that the non-arrival of foreign metal would result in a backwardation have not been realised, although the contango has narrowed to 2s. 6d. It is reported from Belgium that an attempt is being made to form a National Zinc Cartel, but it is yet too early to say what success has attended the movement. There have been no arrivals of Polish spelter, and it may be assumed that the shipments made by the Polish works to Japan are responsible for the slackening in the supplies from that country. The market here, however, can very well dispense for a time with supplies from that country. It is possible there will be some arrivals of Belgian spelter in the near future. The demand from the consuming trades has become distinctly quiet. This is in part attributable to the comparatively small requirements of the galvanised sheet makers. There is a scarcity of Empire brands for prompt delivery, and premiums of about 22s. 6d. are being charged for non-dutiable metal.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. Coast—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 2 0
No. 1	3 9 0	3 2 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
Midlands—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/–rebate*)	3 7 6	—
N.W. Coast—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow	
	4 0 6 „ Sheffield	
	4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
Lancs.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

London and the South—	Home. £ s. d.	Export. £ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¾in. (basis)	9 0 0	7 15 0
„ ⅞in.	9 5 0	8 0 0
„ 1in.	9 10 0	8 5 0
„ 1⅛in.	9 15 0	8 10 0
„ 1¼in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¾in.	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	8 5 0
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 7 6 .. 7 15 0	to 8 5 0

STEEL (*continued*).

Glasgow and District—	Home. £ s. d.	Export. £ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 10 0	8 5 0

Ireland—	Belfast. £ s. d.	Rest of Ireland. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¾in. (basis)	9 0 0	9 2 6
„ ⅞in.	9 5 0	9 7 6
„ 1in.	9 10 0	9 12 6
„ 1⅛in.	9 15 0	9 17 6
„ 1¼in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home. £ s. d.	Export. £ s. d.
Sheets.		
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2 to 19/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£33 0 0	11/–
„ „ „ 1 p.c. carbon	£36 0 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 19 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, February 27th.

Copper—		
Cash	£27 6 3 to £27 7 6	
Three months	£27 12 6 to £27 13 9	
Electrolytic	£30 12 6 to £30 15 0	
Best Selected Ingots, d/d Birmingham	£30 10 0	
Sheets, Hot Rolled	£56 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
Brass—		
Ingots, 70/30, d/d Birmingham	£26 0 0 to £28 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8½d.	8½d.
„ Brazed	10½d.	10½d.
Tin—		
Cash	£215 15 0 to £216 5 0	
Three months	£212 10 0 to £212 15 0	
Lead (Cash and Forward)	£10 6 3	
Spelter	£11 13 9 to £11 16 3	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	16/6
„ „ Splint	17/6
Ayrshire—	
(f.o.b. Ports)—Steam	14/– to 14/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—Prime Steam	14/–
Unscreened Navigation	12/6 to 13/–
Lothians—	
(f.o.b. Leith)—Hartley Prime	14/– to 14/6
Secondary Steam	13/– to 13/6

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	15/– to 17/6
Northumberland, Newcastle—	
Blyth Best	14/3 to 14/9
„ Second	13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

Sheffield—	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	17/6 to 19/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	34/– to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	10/6 to 11/–
Steam Coals:	
Large	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Price and Quality.

THE law of supply and demand is having the inevitable result of bringing down prices through the supply leaving a surplus that must be disposed of at any sacrifice. It has demolished the organisation for the sale of merchant bars and steel sections in Paris, which the mills and forges had imposed on dealers, and it is affirmed that the trouble arose through some producers being more anxious to sell than to help merchants to maintain prices. This experience supports the allegation that while agreements amongst producers offer no difficulty in times of good trade, when they are not wanted, they tend to break down when it is most necessary for them to operate successfully. The fact that prices have slumped all round will inevitably make consumers refractory when business becomes normal again and makers endeavour to return to the former price level, but as one effect of the crisis is to bring about a maximum compression of production costs, it is not likely that manufacturers will need to return to that level, so that finally the advantage in costs enjoyed by some foreign competitors will be reduced and may disappear altogether when the world's currencies settle down to something like common values. Meanwhile, one result of the economies imposed by competitive offers is to enable makers of higher resistance structural steels to supply such material at prices which, they affirm, must necessarily give an impetus to its employment in all cases where there is an advantage in reducing weight without sacrifice of structural strength. Under present conditions, which make it difficult for French manufacturers to compete in the world markets, there is a strong movement in favour of introducing new high-grade materials which will give a character of quality to French productions. On the other hand, there are plenty of examples in the lighter branches of engineering of successful price competition by small makers who are not burdened by overhead charges. There is now a tendency to decentralise industry in a manner to bring out the qualities of skilled labour and give the fullest scope to quality of production, and conferences are being held to stress the importance of quality as a means of enabling French industries to resume the place in the world's markets which they lost through restrictions imposed on foreign trade. This quality propaganda may have some permanent effect on French production, but it will not prevent French industry from adapting itself, in other ways, to new economic conditions that may arise.

Tunnelling Mont Blanc.

The proposal to drive a tunnel for road traffic through Mont Blanc, and provide a direct route between Paris and Rome, has been introduced into the Chamber of Deputies with a demand that the Government should take immediate steps to put the project in hand. According to plans that accompany the proposal, the road from Chamonix will be carried through two short spiral tunnels and an open road by the side of the mountain, protected from avalanches by a pent roof of reinforced concrete, to an altitude of 1240 m. At that point a tunnel, 7½ miles long, will traverse the mountain to the village of Entreves, where an existing road descends to the Valley d'Aosta. The distance between Chamonix and Entreves would be nearly 12 miles. It is declared that there is no reason to anticipate geological difficulties in carrying out the work. There will be two tunnels for one-way traffic having a diameter of 21ft., and they will be joined at distances of a kilometre by short galleries, so that traffic will not be interrupted in the event of any one section of the tunnel being blocked or under repair. An elaborate system of ventilation is proposed with a view to keeping down temperature and evacuating engine exhaust. The construction of the tunnel must depend upon the possibilities of road traffic, which may have to be restricted to touring cars if the Swiss authorities maintain their objection to the tunnel being used for goods traffic, on the ground that an existing agreement between Switzerland and France provides that no new tunnel shall divert such traffic from the Simplon.

The Steel Cartel.

The drop in steel exports leaves an impression that foreign buyers are holding aloof in the belief that the Steel Cartel is passing through a critical period and may only survive by a readjustment of quotas. German producers insist upon a rearrangement which was provided for in the event of the Saar returning to Germany, and, moreover, they affirm that the Cartel is no longer adapted to the changed conditions of foreign trade as evidenced by the increasing prevalence of barter. The Germans insist that business done by barter should be excluded from the quota. French steel makers are desirous of maintaining the Cartel on its present lines, but the return of the Saar to Germany threatens complications through the German claim to retain the privilege of exporting Saar steel to France. The future of the Cartel is believed to be in the hands of British steel makers, who will, it is said, meet Continental representatives at Cannes next week. The suggested raising of duties on steel imported into Great Britain is causing concern, and efforts will be made to come to an agreement with British steel makers before it is too late.

Heavy Oil Aircraft Engines.

The rules for the competition open to French makers of heavy oil aircraft engines, which has been initiated by the Air Ministry, with a prize of 10 million francs for the successful engine, are now published. The prize will be awarded to the competitor beating the world air record over a circular course of 10,000 kiloms., or if the record is not beaten by the end of December of next year the prize will go to the maker of the engine attaining the best average speed over the same course on condition of its equalling or exceeding 180 kiloms. an hour. If the successful engine is built under a foreign licence the prize will be reduced by one half, and in the event of the competition being won by an engine constructed in a State factory or arsenal a prize of 8 million francs will be awarded to the next competitor fulfilling the conditions of the test. All rights in the winning engine will become the property of the State.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

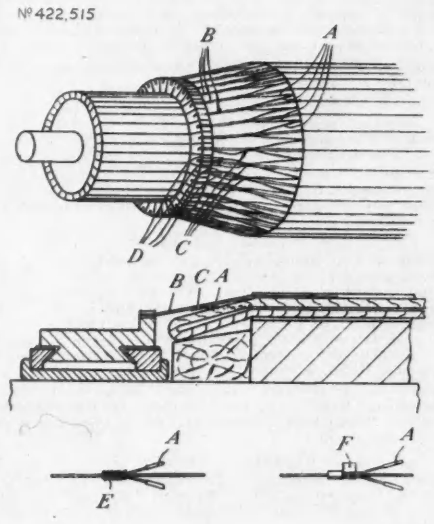
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

422,515. February 7th, 1934.—ARMATURES FOR DYNAMO-ELECTRIC MACHINES, Robert Bosch Aktiengesellschaft, of 4, Militärstrasse, Stuttgart, Germany.

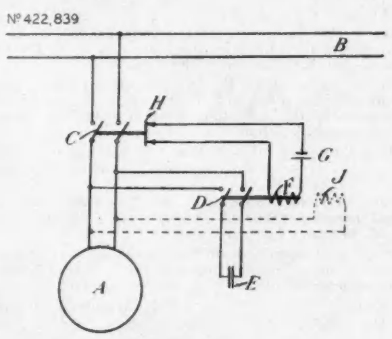
In dynamo-electric machines which are subject to great shocks or vibrations, for example, in the driving motors of hand-supported electric hammers, the durable connection of the ends of the armature coils or conductors to the bars or segments of the commutator presents considerable difficulties. According to the invention, the ends of the armature coils or conductors are free and not shrouded by the armature slots or other obstruction, and partly or wholly bridge the free space between the slots and the commutator, being united to and electrically connected with supporting wires of steel, spring steel or material of similar permanent elasticity, wholly or partly bridging the space and parallel with the conductors, or substantially so.



The winding ends A are connected in the example shown to the supporting wires B, provided by soldering at the points C. The supporting wires B themselves are soldered at one end in slots in the lugs of the commutator bars and at the other end wedged or similarly fastened in the armature grooves. The conductors A may stop off at the soldering point with the supporting wires, as shown in the upper part of the first illustration, or, as shown in the lower part, may extend, as at D, beyond this point and be secured with the ends of the supporting wires in the lugs of the commutator bars. The method of the soldering will be understood from the sketches below, in which in one case the coil ends A are fastened to the supporting wires B by a lapping E of thin wire, and then soldered. In the other case the coil ends A are held to the supporting wire by a copper sleeve F, shown half uncoiled.—*January 11th*, 1935.

422,839. October 5th, 1934.—WATTLESS CURRENT COMPENSATED ELECTRIC MACHINES, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

An arrangement for avoiding excess voltages which occur by the self-excitation of electric machines compensated by wattless current compensators is described in this specification. A machine A is connected to the supply lines B through a main switch C. To the terminals of the machine through a further switch D a wattless current compensator E is connected in such a manner that it will be separated from the supply at the same time as the machine by the switch C. The releasing coil F of

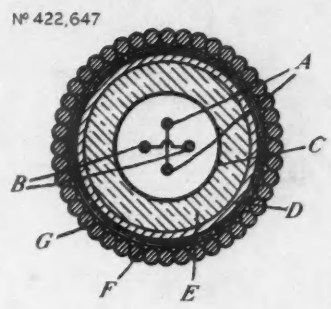


switch D is connected through a current source G to auxiliary contacts H, which are closed when the switch C is open. Thus if the switch C is opened by hand or automatically, then the switch D is also actuated, and thereby the connection between machine B and compensator E is interrupted. As indicated in broken lines, the coil F can be replaced by an excess voltage relay J, which, with the increase of the voltage of the machine to a dangerous amount, opens the switch D. To ensure that the excess voltage relay does not respond also on the closing of switch C under the influence of the switching-in current impulse, it is preferable to give it a small time lag.—*January 18th*, 1935.

TELEGRAPHS AND TELEPHONES.

422,647. November 20th, 1933.—IMPROVEMENTS IN ELECTRIC CABLES, Siemens und Halske Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

It has already been proposed that each of the cores of a double conductor (outgoing and return lines) in a high-frequency cable should be subdivided into two individual conductors and arranged as a spiral quad in which each diagonally disposed pair of individual conductors forms, in the electrical sense, one core of the double conductor. In the cable shown, the pairs of diagonally opposite individual conductors forming the two cores of a double conductor are indicated at A and B, each pair of individual conductors being parallel connected for the high-frequency transmission. A metallic sleeve C constituting a screen is arranged around the double conductor and is insulated from the cable sheath D, which consists, for example, of lead, by

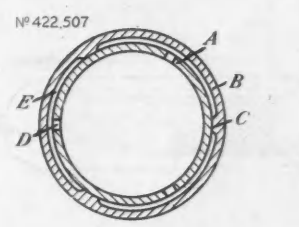


an insulating sleeve E. The screen C can be made in the form of a thin lead sleeve with a continuous surface or it can be made by windings or braidings of metal strips or wires so as to have a closed continuous surface or an open work surface such as is formed by providing spaces between adjacent turns of the windings or between the wires which are braided together, metal sleeves of this character being known in the electric cable art. Around the lead sheath a jute compound layer F and an armouring jacket G of usual construction are successively applied.—*January 16th*, 1935.

TRANSMISSION OF POWER.

422,507. November 23rd, 1933.—OIL-FILLED ELECTRIC CABLES, Allmanna Svenska Elektriska Aktiebolaget, of Vasteras, Sweden.

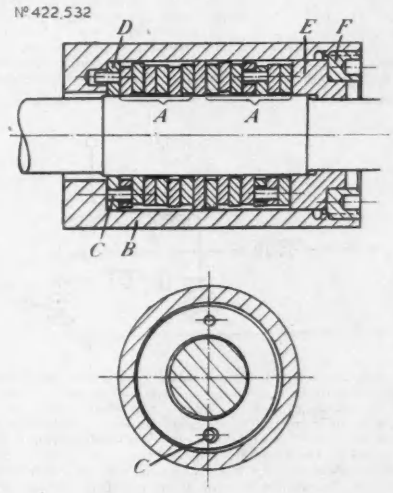
The object of this invention is to use an ordinary oil-insulated, metal-covered cable and to convert it by simple means into a cable which can be laid long distances, and which allows the oil in it to expand and contract and to keep the insulation well saturated with oil under all conditions of service. A is the metal sheath surrounding the conductor and insulation of the cable, which are not shown. The sheath is coaxially surrounded by the outer tube B, having ridges C. By means of holes D in



the sheathing the oil in the interior of the cable is in communication with the intervening space formed between the sheath and the outer tube, and is divided by means of the ridges C into channels for the flow of the oil. The sheath A and the tube B may conveniently consist of lead. The number of perforations per unit of length of the cable and the diameter thereof are determined in such a way that the insulation of the cable is well saturated with oil, both when heated and when cooled. The distances between the perforations in the longitudinal direction of the cable are always many times larger than the diameter of the cable sheath—for instance, 0·5 m. to 20 m.—*January* 14th, 1935.

422,532. June 1st, 1934.—SHAFT BEARINGS, *J. E. Pollak*, 20, *Holborn, London, E.C.*1.

This bearing is intended more especially for the spindles of grinding machines, and the object aimed at is to adjust the bearing to the journal running within it. The bearing is composed of a number of discs A A, which are a loose fit, both on the shaft and in the housing B. The discs are interconnected by

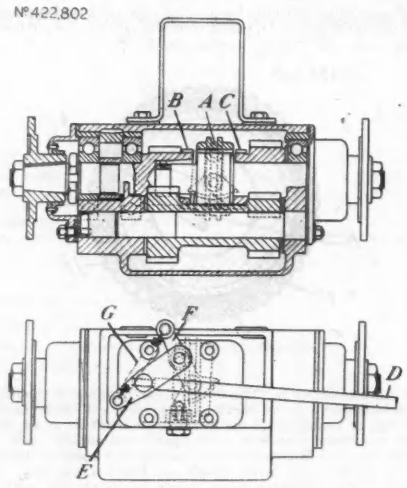


loose-fitting pegs C. The sleeves D and E are of reasonable fit on the shaft and serve to centralise the whole assembly. The bearing surfaces of the discs are brought into contact with the shaft by turning the sleeve E, which is then locked by the threaded ring F. Turning this sleeve moves all the rings eccentrically, and they support the shaft, with crescent-shaped gaps that facilitate lubrication.—*January 14th*, 1935.

422,802. August 30th, 1933.—DOG CLUTCHES AND CHANGE SPEED GEARS, Leyland Motors, Ltd., and J. T. Naylor, Hough-lane, Leyland, Lancs.

This invention concerns a two-speed gear-box for motor vehicles in which the gear wheels are always in mesh and the

changes are effected by a dog clutch. It is claimed that if the faces of the dogs are inclined at an angle, normal to the direction of rotation, of one degree, they will ride over one another when pressed into engagement until the speed of the two parts becomes similar. The dog clutch is shown at A and the two

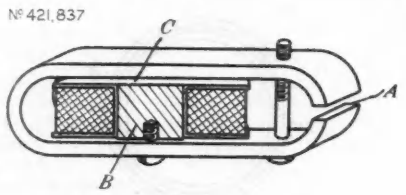


gear wheels with which it may be engaged at B and C. The clutch is moved into engagement in either direction by the rod D. This rod pulls or pushes on the doubly articulated lever system. E F, and the spring G pulls the clutch into engagement in either direction.—*January 18th*, 1935.

MISCELLANEOUS.

421,837. July 31st, 1933.—VARIABLE ELECTRIC INDUCTANCES, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2; and Norman Frank Tilbury Saunders, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

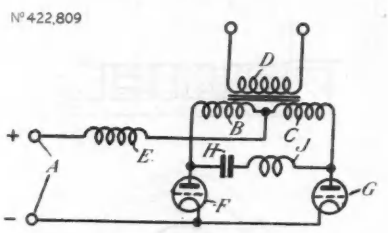
A variable electric inductance according to this invention comprises a winding associated with a core solid or unlaminated throughout an air gap A of which is adjustable by a screw



for the purpose of adjusting the inductance of the winding. The block B is clamped by a screw to the inner surface of one limb and there is a narrow air gap C between the block and the other limb. This air gap is also varied as the screw is turned and in the same sense as the gap A between the ends of the limbs. The winding is arranged around the block B and between the limbs.—*January 1st*, 1935.

422,809. October 23rd, 1933.—ELECTRICAL CIRCUITS, INCLUDING GAS-FILLED ELECTRIC DISCHARGE DEVICES, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2; and Carlton Rosslyn Dunham, of Research Laboratories of the General Electric Company, Ltd., Wembley, Middlesex.

This invention relates to electrical circuits of the type comprising a gas-filled electric discharge device. Means are provided for initiating a current in the anode-cathode circuit of the device, which are not wholly dependent on the potential difference between anode and cathode. It is known that gas-filled thermionic triodes used in circuits of this type are liable to have a short life, which has been associated with the large current that may flow in from the condenser or the like. It has been found that the current, even when its value is still low, is deleterious during a very short period after the initiation of the discharge. The life of the device may be prolonged greatly by reducing the current during this short period, even if the current rises to high values later. According to the invention, in an electrical circuit of the type specified an inductance is placed in series with the condenser or the like, whereby the current flow-



ing through the device is substantially reduced during a short period immediately succeeding the initiation of the current, but is not substantially reduced during the whole period of conduction in the device. The diagram shows a parallel inverter. Current from a D.C. supply A flows alternately through a load constituted by the two halves B C of the primary of the transformer, whose secondary D provides the output. E is a choke preventing alternating current from reaching the supply A. The two gas-filled triodes F and G are made alternately conducting by an alternating supply (not shown) connected to their grids. At the moment when F becomes conducting G is already conducting; H accordingly tends to discharge immediately through F. J reduces the current in the initial stages of the discharge, but it must not reduce it for so long as to prevent H from fulfilling its primary purpose, which is to reduce the anode voltage of G so that the discharge in it stops shortly after the discharge in F starts. For this purpose the effect of J need endure only for a period much less than the whole period of the discharge. In an inverter fed by a 240-volt D.C. supply with a 100-watt output at 50 cycles, if H is 1 μ F, a suitable value for J will be 20 millihenries; the time constant of the condenser and inductance then being about 1 millisecond.—*January 18th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

BRITISH INDUSTRIES FAIR, 1935.—London Section. Daily.

INST. OF FUEL.—At British Industries House Club, Marble Arch, Oxford-street, W.1. Mr. Harold Hobson will open debate on "Is the Expenditure on the Electrical Grid Likely to be Justified?" Mr. W. A. Tookey will be the first speaker for the opposition. 6.30 for 7 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting. Lecture, "Random Notes on Engineering in Greece," Mr. Leslie Turner. 7.30 p.m.

MANCHESTER ASSOC. OF ENGINEERS.—Manchester Limited Restaurant, Royal Exchange, Manchester. Annual dinner and dance. Reception, 7 p.m.; dinner, 7.30 p.m.; dancing, 9.30 p.m. to 1 a.m.

PHYSICAL SOC.—At Imperial College of Science and Technology, S. Kensington, S.W.7. Editing Committee meeting, 3.30 p.m. Council meeting, 4 p.m. Meeting, 4.45 for 5 p.m.

ROYAL AERONAUTICAL SOC.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "Fuels for Aircraft Engines," Mr. E. L. Bass. 6.30 p.m.

SATURDAY, MARCH 2nd.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—At Engineers' Club, Manchester. "Pattern-making: The Craftsman and his Craft," Mr. H. Stead. 4 p.m.

INST. OF MARINE ENGINEERS.—85/88, The Minories, E.C.3. Junior Section dance. 7.30 to 11.15 p.m.

MONDAY, MARCH 4TH.

CHARTERED SURVEYORS' INST.—12, Great George-street, S.W.1. "Fungus Attack and Dry Rot in Buildings," Mr. K. St. G. Cartwright and Dr. R. C. Fisher. 6.30 p.m.

ENGINEERS' GERMAN CIRCLE.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "The Velox Boiler and its Possibilities as Applied to Land and Sea," Herrn. Adolf Meyer. 5.15 for 6 p.m.

TUESDAY, MARCH 5TH.

INST. OF AUTOMOBILE ENGINEERS.—At Royal Geographical Soc., Kensington Gore, S.W.7. Joint meeting with eleven other technical societies. Symposium. "Cold Pressing and Drawing." Papers: (*a*) "From the Mechanical Point of View," Dr. H. Gough, F.R.S.; (*b*) "From the Metallurgical Point of View," Dr. C. H. Desch, F.R.S.; "New Researches on the Drawing of Cylindrical Shells," by Prof. Dr. Ing. G. Sachs. Prof. Sir Harold Carpenter, F.R.S., will take the chair at 7 p.m.

INST. OF CIVIL ENGINEERS.—Great George-street, S.W.1. Discussion, "Major Improvement Works of the Port of London Authority, 1925–1930," Messrs. T. W. D. Davis and W. Mackenzie. 6 p.m.

WEDNESDAY, MARCH 6TH.

INST. OF CIVIL ENGINEERS: STUDENTS' INFORMAL MEETING.—Great George-street, S.W.1. Mr. F. R. Bullen will introduce discussion on "The Practical Considerations Affecting Design." 6.30 p.m.

INST. OF ELECTRICAL ENGINEERS: WIRELESS SECTION.—Savoy-place, W.C.2. "Crystal Oscillators for Radio Transmitters," Messrs. C. F. Booth and E. J. C. Dixon. 5.30 for 6 p.m.

SOC. OF GLASS TECHNOLOGY: LONDON SECTION.—At Offices of Holophane, Ltd., Elveston-street, Westminster. Symposium, "Stoppers, Caps, and Closures." 7.30 p.m.

WEDNESDAY AND THURSDAY, MARCH 6TH AND 7TH.

INST. OF METALS.—Annual general meeting. For programme see February 8th, 1935, page 148

THURSDAY, MARCH 7TH.

INST. OF CIVIL ENGINEERS: YORKSHIRE AND DISTRICT ASSOC.—Hotel Metropole, Leeds. "Sydney Harbour Bridge," Mr. J. Walton. 7.30 p.m.

FRIDAY, MARCH 8TH.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Savoy-place, W.C.2. "High-voltage Alternators," Mr. P. E. Crawshaw Smith. 6.30 for 7 p.m. Visit to the *Daily Herald* Printing Offices. 10 p.m.

INST. OF ELECTRICAL ENGINEERS: N.-EASTERN STUDENTS.—County Hotel, Neville-street, Newcastle-upon-Tyne. Second annual dinner. 7.30 p.m.

INST. OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Hotel Metropole, Leeds. Annual dinner. 7 p.m. for 7.30 p.m.

INST. OF MARINE ENGINEERS.—85/88, The Minories, E.C.3. Annual general meeting. 6 p.m.

INST. OF METALS: SHEFFIELD LOCAL SECTION.—At University, Sheffield. "Electric Annealing and Heat Treatment Furnaces," Mr. A. G. Lobley. 7.30 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, S.W.1. Informal meeting. Prof. B. P. Haigh will introduce discussion on "Recent Work in Testing Steel of Mild and Moderate Tensile Strength." 7 p.m.

INST. OF PRODUCTION ENGINEERS.—British Industries House Marble Arch, W.1. "Modern Wood Production Methods," Mr. C. Williams. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting, "The Construction of a Modern Liner," Mr. E. H. Brooks. 7.30 p.m.

NORTH-EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS.—At Mining Inst., Newcastle-upon-Tyne. "Flying Boats and their Possible Developments," Mr. A. Gouge. 6 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Discourse, "Future of British Agriculture," Sir John Russell. 9 p.m.

SOC. OF CHEMICAL INDUSTRY.—In Chemical Dept. of Liverpool University, Liverpool. Symposium on Meat, "The Chemistry of Meat." Papers by Dr. E. C. Smith and Mr. L. C. Baker. 3–5 p.m. "Meat Storage." Papers by Dr. T. Moran and Mr. Hal Williams. 6–7 p.m.

SATURDAY, MARCH 9TH.

FINSBURY TECHNICAL COLLEGE OLD STUDENTS' ASSOC.—Trocadero, W.1. Annual dinner. Full particulars from F. R. C. Rouse, 15, Clifton-gardens, Golders Green, N.W.11.

MONDAY, MARCH 11TH.

BRADFORD ENGINEERING SOC.—Technical College, Bradford. "The Adaptability of Pressure Piles for Underpinning and Strengthening Foundations," Mr. G. Ivan Cope. 7.30 p.m.

INST. OF METALS: SCOTTISH LOCAL SECTION.—At 39, Elmbank-crescent, Glasgow, C.2. Annual general meeting. Paper, "Welding," Dr. J. H. Peterson. 7.30 p.m.

STEPHENSON LOCOMOTIVE SOC.—King's Cross Station, N.1. "Railway Snapshots: Ancient and Modern," Mr. A. E. L. Thorne. 6.30 p.m.

TUESDAY, MARCH 12TH.

INST. OF AUTOMOBILE ENGINEERS.—King's Head Hotel Coventry. "Small Marine Engines," Mr. A. G. Pendrell. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Municipal College, Ormerod-road, Burnley. A brief description of Sand Testing Apparatus recommended by the B.C.I.R.A. and used by students of Burnley Municipal College, Mr. G. Whittaker; and "Metal as Liquids: The Application of Laws Governing Liquids Applied to Liquid Metals," Mr. H. Buckley. 7.15 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. "A Diesel-electric Paddle Ferry Boat," Mr. M. E. Denny. 7.30 p.m.

INST. OF MARINE ENGINEERS.—85/88, The Minories, E.C.3. Symposium on "High-pressure Boilers." 6 p.m.

INST. OF METALS: N. EAST COAST LOCAL SECTION.—In the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne. Discussion, "The Improvements of White Bearing Metals for Severe Service: Some General Considerations," Mr. D. J. Macnaughton. 7.30 p.m.

INST. OF METALS: SWANSEA LOCAL SECTION.—At Y.M.C.A., Swansea. Annual general meeting. Paper, "Some Recent Developments in the Hardening of Non-ferrous Metals by Heat Treatment," Mr. W. T. Griffiths. 6.15 p.m.

ROYAL AERONAUTICAL SOC.—Joint meeting with the Illuminating Engineering Soc., at Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Recent Developments in the Lighting of Airways and Aerodromes." 6.30 p.m.

WEDNESDAY, MARCH 13TH.

INST. OF CIVIL ENGINEERS.—Students' afternoon visit to the blast-furnaces of the Ford Motor Company, Dagenham.

THURSDAY, MARCH 14TH.

INST. OF AUTOMOBILE ENGINEERS.—Merchant Venturers' Technical College, Bristol. "Small Racing Cars," Mr. H. N. Charles. 7.30 p.m.

INST. OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOC.—James Watt Memorial Inst., Birmingham. "Vibrations in Engineering Structures," Prof. C. E. Inglis, F.R.S. 5.30 for 6 p.m.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—85/88, The Minories, E.C.3. "The Manufacture and Testing of Steel Forgings," Dr. W. H. Hatfield. 7 p.m.

INST. OF METALS: LONDON LOCAL SECTION.—In Rooms of Soc. of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. "Failures in Service," Dr. H. J. Gough, F.R.S. 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS: STUDENTS.—Manchester Limited Restaurant, Royal Exchange, Manchester. Annual social and dance.

FRIDAY, MARCH 15TH.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting. "Old-time Engineers and Experiments," Mr. A. W. Marshall. 7.30 p.m.

RAILWAY CLUB.—At Royal Scottish Corpn. Hall, Fetter-lane, E.C.4. "An Introduction to Railway Heraldry," Mr. G. W. J. Potter. 7.30 p.m.

SATURDAY, MARCH 16TH.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND STUDENTS.—Visit to Jowett Cars, Ltd., Idle, Bradford. Permit cards may be obtained from Mr. W. Chambers, 22, St. Ann's-mount, Leeds, 4.

MONDAY, MARCH 18TH.

ENGINEERS' GERMAN CIRCLE.—At Inst. of Mechanical Engineers', Storey's-gate, S.W.1. "New Trends of Development in German Refrigerator Design," Prof. Dr. Ing. R. Plank. 5.15 for 6 p.m.

INST. OF AUTOMOBILE ENGINEERS.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "Small Marine Engines," Mr. A. G. Pendrell. 7.45 p.m.

LAUNCHES AND TRIAL TRIPS.

ROSA, twin-screw steam tank ship; built by the Netherland Shipbuilding Company, Ltd., to the order of the Royal Shell Group; dimensions, 335ft. by 56ft. by 22ft. 6½in.; to carry oil in bulk. Engines, steam; constructed by Werkspoor N.V.; trial trip, February 11th.

JEAN BRILLANT, single-screw motor vessel; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of La Cie de Transport du Bas St. Laurent, Ltd., of Quebec; dimensions, 168ft. by 29ft. by 18½ft.; to carry passengers and cargo. Diesel engines of Neptune Polar type; constructed by the builders; launch, February 19th.

SAN ARCADIO, single-screw motor oil tanker; built by Harland and Wolff, Ltd., to the order of Eagle Oil and Shipping Company, Ltd.; dimensions, 442ft. 6in. by 60ft. by 32ft.; to carry oil in bulk. Diesel engines of Harland-B. and W. type; constructed by the builders; launch, February 19th.

PUCK, single-screw steamer; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Zegluga Polska Spolka Akcyjna, of Gdynia, Danzig; dimensions, 243ft. by 36ft. 6in.; to carry cargo. Steam engines of compound reciprocating type, working in conjunction with a low-pressure exhaust turbine on Bauer-Wach system; constructed by the builders; launch, Feb. 21st.

ROTHESAY CASTLE, motor vessel; built by Harland and Wolff, Ltd.; to the order of Union-Castle Mail Steamship Company, Ltd.; dimensions, 445ft. by 61ft. by 36ft. 9in.; to carry cargo. Diesel engines of Harland-B. & W. type; constructed by the builders. Launch, February 21st.

SAN ADOLFO, single-screw motor vessel; built by Furness Shipbuilding Company, Ltd.; to the order of the Eagle Oil and Shipping Company, Ltd.; dimensions, 442ft. 6in. by 60ft. by 32ft.; to carry oil in bulk. Diesel engine, constructed by Hawthorn, Leslie and Co., Ltd. Launch, February 21st.

BRITISH IRON AND STEEL FEDERATION.—At the annual general meeting of the British Iron and Steel Federation, held in London on February 21st, the Right Hon. the Earl of Dudley, chairman of the Earl of Dudley's Round Oak Works, Ltd., was elected President for 1935. The following were elected Vice-Presidents:—Sir John Beale, chairman, British (Guest Keen Baldwins) Iron and Steel Company, Ltd.; Captain R. S. Hilton, managing director, United Steel Companies, Ltd.; Sir Charles Craven, deputy chairman and managing director, English Steel Corporation, Ltd.; Mr. Lawrence Ennis, managing director, Dorman, Long and Co., Ltd.; Sir William Firth, chairman, Richard Thomas and Co., Ltd.; Mr. J. E. James, chairman, Lancashire Steel Corporation, Ltd.; Mr. C. W. Kayser, chairman and managing director, Kayser Ellison and Co., Ltd.; Sir James Lithgow, director, Colvilles, Ltd.; Mr. A. K. McCosh, director, Wm. Baird and Co., Ltd.; Mr. A. C. Macdiarmid, chairman, Stewarts and Lloyds, Ltd.; Mr. Henry Summers, chairman, J. Summers and Son, Ltd.; Mr. A. J. Wesson, chairman and managing director, W. Wesson and Co., Ltd. Sir William B. Peat was elected first Honorary Vice-President of the Federation.